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YELLOW WATER DAM

MANUAL FOR OPERATION AND MAINTENANCE

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**Initial Publication March 1998
Revised September 2007**

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YELLOW WATER DAM

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**State Water Projects Bureau
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P. O. Box 201601
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48 North Last Chance Gulch
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PROJECT DESCRIPTION

OVERVIEW

Yellow Water Reservoir is located in Petroleum County approximately eight miles southwest of the town of Winnett, Montana (and about six miles west of Highway 244). It is located on and fed by Yellow Water Creek and Snoose Creek. See Figures 1 and 2. Figure 3 provides a general layout of the dam, spillway and outlet works.

The dam is owned by the Montana Department of Natural Resources and Conservation (DNRC) and managed by the State Water Projects Bureau (SWPB) of the DNRC. The Yellow Water Water Users Association (herein called the “association”) operates and maintains the dam.

Water from the reservoir is primarily used for irrigation water supply. The reservoir also is used for water-based recreation.

EMBANKMENT

The earthfill dam and dike were completed in 1938. The dam is 37 feet high and 1,695 feet long, while the dike is 11 feet high and 545 feet long. In 1970, a riprap facing and gravel filter blanket were designed by the Soil Conservation Service for the upstream slope of the embankment.

OUTLET WORKS

The outlet works consist of a concrete intake structure, a 42-inch diameter reinforced concrete conduit, a wet well control tower, an outlet structure, and an irrigation water delivery canal. The wet well control tower contains a 42-inch diameter slide operating gate, flashboard guides and a ladder. The opening at the top of the

control tower is protected with a metal cover. The gate operating mechanism is located at the dam crest on top of the tower, and is operated manually with a hand crank.

Water released from the reservoir is conveyed downstream by a canal. There is a canal gate approximately 200 feet down the irrigation canal, that when opened, the water will flow into Yellow Water Creek.

The original outlet conduit was a corrugated metal pipe. The deteriorated pipe was replaced in 1985 with a 42-inch-diameter reinforced concrete pipe. The construction was done in two phases. Phase I was the excavation of the embankment and removal of the old pipe. Phase II consisted of installing the 42-in concrete pipe, constructing new inlet and outlet structures, cleaning the outlet gate, replacing the embankment, placing riprap on the upstream face of the dam, and seeding the disturbed area. The total cost, including the engineering design, field construction inspection, and both phases of construction, was \$200,000.

SPILLWAY

The spillway for the dam is located to the right (south) of the dam embankment between two dike sections. The spillway channel was relocated in the spring of 1979 as a corrective measure for localized erosion. Its entrance occupies approximately the same position as the old spillway, but then aligns in a north-south direction.

The spillway is an earthen, broad-crested, uncontrolled outflow system. The channel is trapezoidal in shape with a minimum base width of 95 feet and has approximate side slopes of 4h:1v. The spillway channel is contained by a natural ground floor, an old dike section on the right (east) side, and a new dike section on the left (west) side. The channel was excavated a short distance

into sandy shale material, which should reduce the erosion potential along the flow line. The channel extends approximately 500 feet on nearly a horizontal slope from the inlet to a point where the channel transitions to natural terrain. From there, the spillway discharge travels primarily as overland flow until returning to the Yellow Water Creek channel and flood plain.

The spillway capacity at elevation 3,123.84 feet is 3,900 cfs. The spillway rating table is in Appendix A.

DRAINS

A rock toe drain runs along the southern two-thirds of the dam. The drain system is located at the base of the pervious fill section for controlled collection and discharge of seepage water to the pervious rock toe. The drain runs parallel to the dam axis. The drawings for the dam show that the rock toe drain is connected to the internal toe drain by a number of lateral gravel connector drains which are perpendicular to the axis. Seepage from the drain flows into the pond located about 100 feet downstream from the dam.

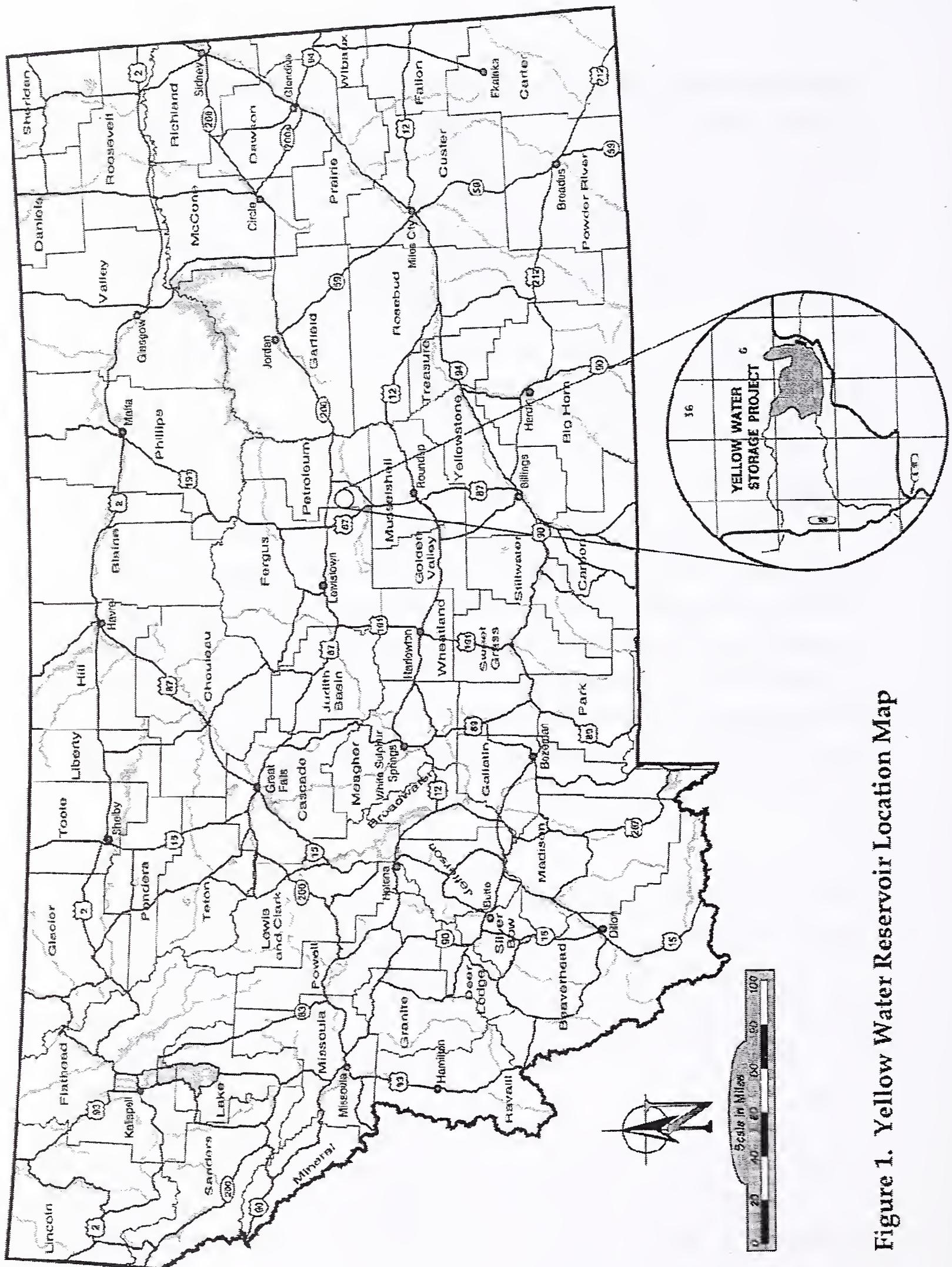


Figure 1. Yellow Water Reservoir Location Map

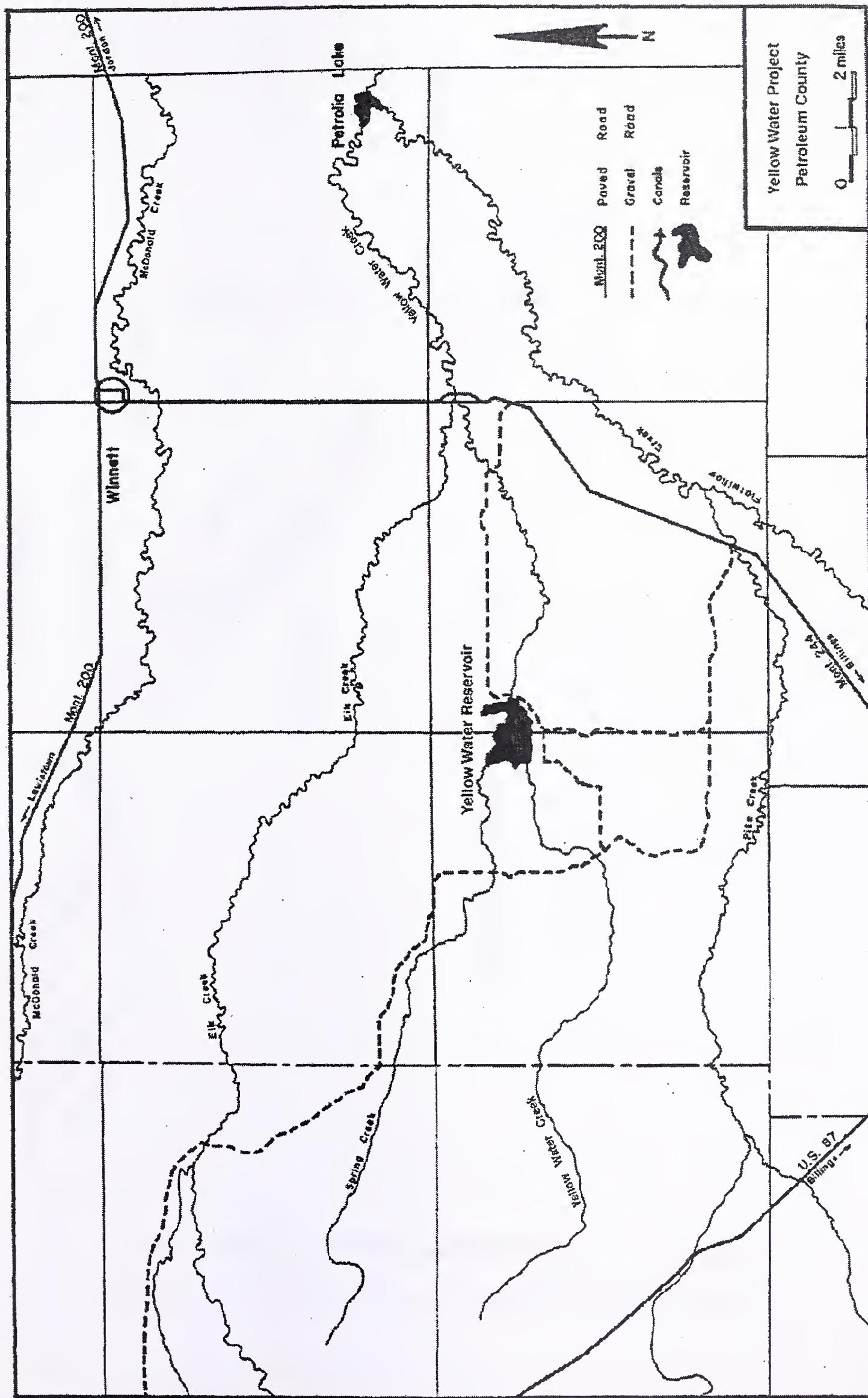


Figure 2. Yellow Water Project Map

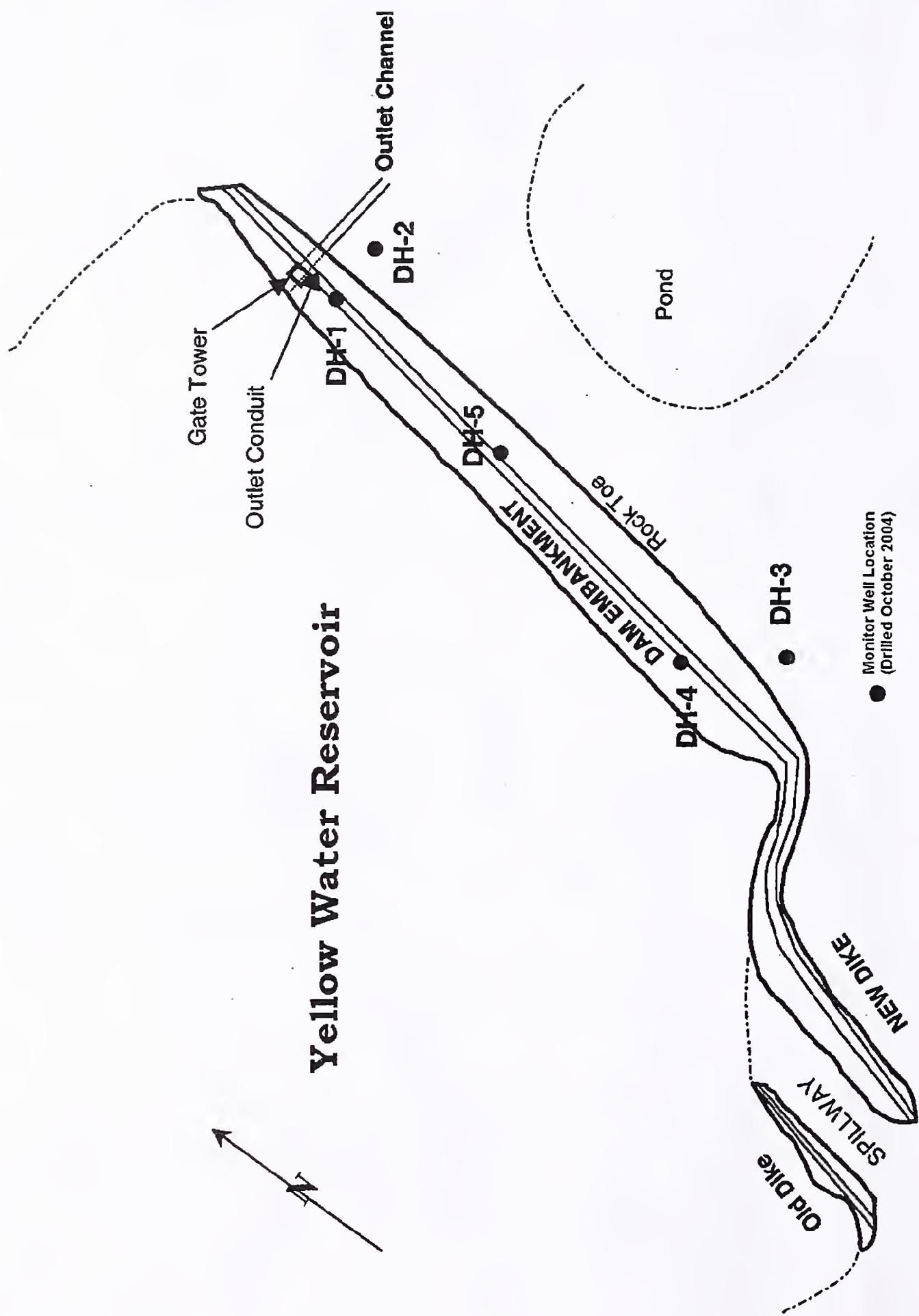
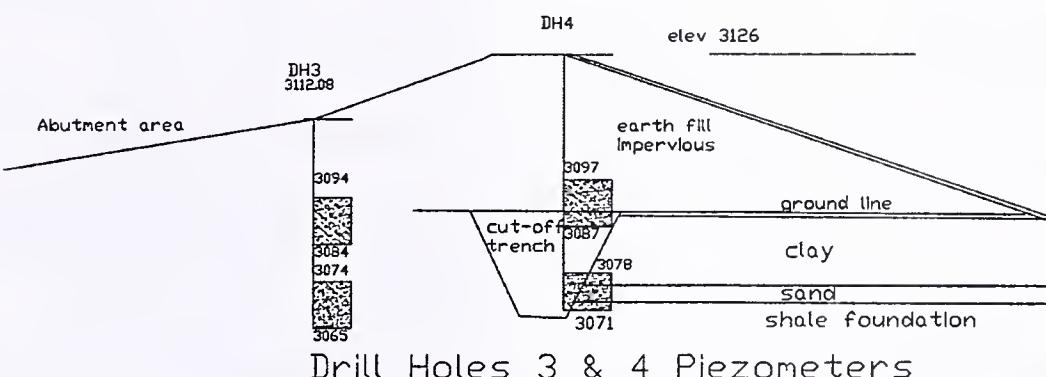
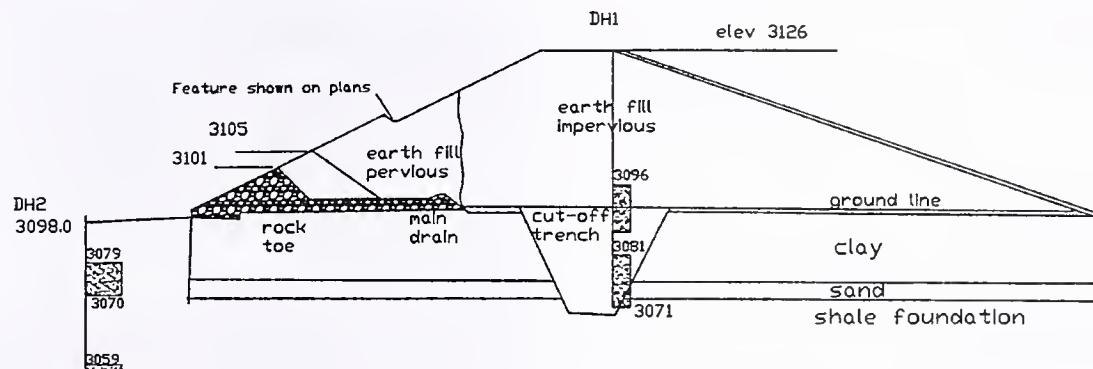
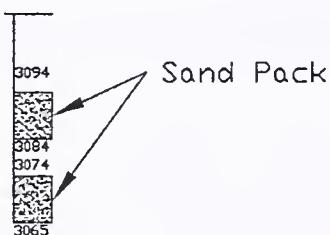


Figure 3. Yellow Water Dam General Layout



Legend



| | | |
|--|-----------------------------|-----------------|
| JOB NAME: YELLOW WATER RESERVOIR | DRAWN BY: KAP | CHECKED BY: |
| LOCATION: PETROLEUM COUNTY, MT | SCALE: NTS | |
| DATE: JULY 24, 2007 | | |
| DESCRIPTION: PIEZO SECTIONS | JOB NUMBER 5 YEAR REPORT | SHEET 1 OF 1 |

Figure 4. Yellow Water Dam Cross Section

STATISTICAL INFORMATION

1. General

| | |
|--------------------------|--|
| a. Owner | Montana Department of Natural Resources and Conservation (DNRC) |
| b. Operator | Yellow Water Water Users Association |
| c. Location | Section 7, Township 13 North, Range 26 East and Section 12, Township 13 North, Range 25 East |
| d. Latitude Longitude | 46.91° 108.47° |
| e. County--State | Petroleum—Montana |
| f. Watershed Location | Yellow Water Creek-Flatwillow Creek-Musselshell River, Missouri River basin |
| g. Drainage Area | 55 square miles |

2. Principal Elevations (feet above mean sea level)

| | |
|---------------------------|--------------|
| a. Maximum Dam Crest | 3,126.5 feet |
| b. Top Outlet Works Tower | 3,125.0 feet |
| c. Minimum Dam Crest | 3,124.8 feet |
| d. Normal Full Pool | 3,118.6 feet |
| e. Spillway Crest | 3,118.6 feet |

3. Reservoir

| | |
|--|--|
| a. Length of Maximum Pool (approximate) | 1.5 miles |
| b. Maximum Reservoir Level of Record | 3,119.0 feet, estimated (before spring 1979) |
| c. Surface Area (at normal full pool) | 490 acres |

4. Storage

| | |
|--|-----------------|
| a. Maximum Pool (pool at dam crest) | 6,603 acre-feet |
| a. Total Storage (pool at spillway crest) | 3,842 acre-feet |
| b. Active Storage (total storage minus dead storage) | 3,835 acre-feet |
| c. Dead Storage (pool at invert of Intake structure) | 7.0 acre-feet |

5. Hydrology

| | |
|----------------------------------|-----------|
| a. 100-Year Flood | 2,288 cfs |
| b. 500-Year Flood | 4,587 cfs |
| c. 0.3 Probable Maximum Flood | 9,168 cfs |

6. Embankment (Dam)

| | |
|---|------------|
| a. Type | Earthfill |
| b. Hydraulic Height | 37 feet |
| c. Crest Length | 1,695 feet |
| d. Crest Width | 14 feet |
| e. Downstream Slope | 1v on 2h |
| f. Upstream Slope (above Elev. 3,113.5 feet) | 1v on 2h |
| g. Upstream Slope (below Elev. 3,113.5 feet) | 1v on 3h |

7. Embankment (Dike)

| | |
|---------------------|-------------------------------|
| a. Type | Earthfill |
| b. Hydraulic Height | 11 feet |
| c. Crest Length | 545 feet |
| d. Crest Width | 20 feet |
| e. Downstream Slope | Varies from 1v on 2h to 1v on |

| | |
|-------------------|----------------------------------|
| f. Upstream Slope | 4h |
| | Varies from 1v on 2h to 1v on 4h |

8. Spillway

| | |
|---|--------------|
| a. Control | None |
| b. Crest Elevation | 3,118.6 feet |
| c. Capacity (at pool Elev. 3,125.0 feet) | 3,900 cfs |

9. Outlet Works

| | |
|---|--|
| a. Size | 42-inch diameter reinforced concrete pipe |
| b. Length | 150 feet |
| c. Control | One 42-inch diameter slide gate valve with manual operator |
| d. Capacity (at pool Elev. 3,125.0 feet) | 192 cfs |
| e. Design Invert Elevation | 3,094.22 feet |
| f. Top of Tower | 3,125.0 feet |
| g. Trashrack | Yes |

10. Brief History

- a. The Yellow Water project was designed by the State Water Conservation Board (SWCB) in 1934 with construction starting December 4, 1935 and completed June 1938. It was constructed by the Civilian Conservation Service with SWCB oversight. The project lay dormant until 1947. This water impoundment structure was placed based on agricultural and economic needs.
- b. In 1979, the original spillway was eroding and starting to threaten the embankment. A new spillway was configured running parallel to the embankment utilizing the original spillway entrance. This new alignment was reported to have a few areas of negative grade thus reducing its capacity.

c. In 1980 the USACOE funded a Dam Inspection; HKM Associates performed said inspection and condemned the outlet as it was in danger of failure due to corrosion of the original CMP. In 1984, the SWP hired Morrison Maeirle of Helena, Montana to design a new conduit and terminal outlet structure and in 1985 it was replaced with the present outlet structure.

d. In 2004 the SWP installed 5 wells each with deep and shallow piezometers. Since that time the water impoundment structure has not filled.

OPERATING PROCEDURES

The association manages Yellow Water Dam to insure safe operation of the project and to provide an adequate supply of irrigation water to meet contracts with water users without exceeding safe storage or flow levels.

DAM OPERATOR

The responsibility for the daily operation of the dam and reservoir rests with the association and its dam operator. The dam operator is generally authorized to operate the reservoir to meet the association's goal of providing an adequate supply of water when called for by the association members. Specific responsibilities of the dam operator are as follows:

1. Operate the mechanical features of the outlet works
2. Coordinate filling of the reservoir and the release of water
3. Notify the SWPB of unusual occurrences such as impending floods or excessive seepage.
4. Perform certain maintenance tasks.
5. Monitor weather conditions.
6. Monitor seepage.

Typically, the out-going dam operator, the water users association, and the SWPB train a new dam operator. The dam operator's training focuses on the mechanical operation of the gate, measurement of the storage level, measurement of the rate of water release, daily observation of unusual conditions, and record keeping.

The dam operator normally is available to observe the dam and perform operating functions daily during the times of rapid reservoir filling. During the remainder of the filling and irrigation season, the operator is at the dam three to five times per week.

During the non-irrigation season, the dam operator or one of the directors observe and regulate the dam on a monthly basis.

Communication among the dam operator, the association, and the SWPB usually takes place by telephone. Radio communication may be established during emergencies or unusual occurrences so that the dam operator can speak directly with county authorities and with the SWPB (**see *Yellowwater Dam Emergency Plan***).

METHOD AND SCHEDULE OF OPERATION

The association's goal is to have the reservoir full before contract holders start putting in calls for water. The beginning date of irrigation releases varies from year to year, with mid-April being the earliest month during which irrigation releases begin. The last irrigation releases typically are made by September 1. All dates tend to vary depending on a year's actual climatological and hydrological conditions.

Maximum Winter Storage: The maximum winter storage is 3,116 feet with 2,943 acre-feet of storage. This winter maximum helps prevent damage to the riprap and embankment from wind-driven waves and ice.

Minimum Water Storage: The minimum winter storage is 3,101.7 feet with 207 acre-feet of storage. This winter minimum helps prevent ice damage to the inlet structure for the outlet works, minimizes water quality problems, and helps to maintain the fishery.

GATE OPERATION

The maximum amount the operating gate may be opened is 42 inches. An opening in excess of this amount may damage the gate, gate frame, gate stem or the gate pedestal. The gate opening is measured on the exposed portion of the gate stem between the top of the pedestal and the bottom of the stop nut (or top of the gate stem if there is no stop nut).

Water released from the reservoir is conveyed downstream by a canal. The maximum capacity of the canal without overtopping the canal banks is approximately 45 cfs. If the outlet works are operated far in excess of the delivery canal's capacity, the canal and structures may be damaged.

With the reservoir pool at the dam crest, the capacity of the outlet works is 192 cfs. An outlet rating table is in Appendix A. The outlet works are intended to be used for controlling the release of irrigation water and not for providing emergency relief.

SAFE DRAWDOWN

Since the stability of Yellow Water Dam has not been thoroughly investigated, drawdown rates are recommended not to exceed one foot per day.

STORAGE DETERMINATION

If water is not being diverted, storage and reservoir surface elevation can be determined by measuring from the top of the control tower to the water surface in the tower. The top of the control tower is at elevation 3,125.0 feet. Subtract the vertical distance to the water surface from 3,125.0 to find the elevation of the water surface. Once the reservoir surface elevation is determined, the reservoir storage is found using the Storage-Elevation Table (Table 1) in Appendix A.

If water is being diverted, the water surface in the control tower will be lower due to drawdown from the open operating gate. An accurate vertical distance to the water surface cannot be obtained.

INFLOW AND OUTFLOW MONITORING

There are no stream gages upstream or downstream of Yellow Water Dam.

WEATHER MONITORING

The dam operator monitors weather conditions through local weather forecast and the National Weather Service (NWS).

If severe flooding is anticipated, the NWS Glasgow Office **(1-406-228-9622 or 1-406-228-2850)** should be contacted for information about the storm, such as the estimated storm intensity and duration, runoff duration (above base flow), and total flood volume of the storm in the Yellow Water Creek drainage.

INTERACTION WITH OTHER DAMS

Other then irrigation diversion dams, there are only two dams located below Yellow Water Reservoir (at least within the boundaries of Montana). Petrolia Dam is 22.2 river miles downstream, and Fort Peck Dam is further downstream on the Missouri River.

Yellow Water Reservoir is the only storage facility of size upstream of Petrolia Dam. The safety of Petrolia Dam is not generally a concern during the normal operation of Yellow Water Reservoir. The amount of water that can be released by Yellow Water Reservoir can easily be handled by Petrolia.

The safety of Fort Peck Dam is not affected by the operation of Yellow Water Reservoir during either normal or emergency operations.

EMERGENCY

If it appears that the dam or dike at Yellow Water is about to breach, or during emergency operations, the dam operator will initiate the **Yellow Water Dam Emergency Action Plan**.

INSPECTION AND MONITORING

Annual inspections are conducted by the SWPB. Appendix B includes an example of SWPB inspection report form. In addition to annual inspection, SWPB personnel will inspect the dam and reservoir during and after heavy runoff and severe rainstorms and windstorms, during high storage periods, and after an earthquake.

STRUCTURAL FEATURES INSPECTION

Structural features include the wet well, spillway, outlet works, and canal headgate. The SWPB inspects these structures annually as part of its inspection program. Items to be checked or noted include, but are not limited to:

1. Outlet Works
 - a. Any differential settlement or movement resulting in cracking of the conduit
 - b. Erosion of the seals or concrete by cavitation immediately downstream of the gate
 - c. Seepage of water into or along the conduit
 - d. Deterioration of exposed concrete due to freeze/thaw cycles or sulfate reactions
 - e. Operation of the gate
 - f. Air vent free and unobstructed operation
 - g. Corrosion of any metal
 - h. Proper lubrication and cleaning of gate pedestal
2. Wet Well-Any damage or vandalism
3. Spillway
 - a. Erosion sides and bottom
 - b. Accumulation of debris or sediment
4. Embankment
 - a. Erosion gullies in dam and dike face
 - b. Damage from burrowing animals or vegetation

- c. Displacement or loss of rip-rap protection
- d. Displacement of fill, sink holes, or slumps

It is important to note settlement or slumping in the area above the outlet pipe which was disturbed when the outlet conduit was replaced in 1985.

- e. Any seepage.

RIPRAP INSPECTION

The riprap along the face of the dam and dike should measure at least 24 inches thick. Immediately after the occurrence of high water, the riprap should be inspected and additional riprap added if needed.

EMBANKMENT MONITORING POINTS

There are no monitoring measurement points on the dam embankment.

DRAINS

The drain system for the dam consists of an internal “main drain” constructed of select gravel, select gravel lateral drains, and a pit run gravel and rock toe drain along the middle 2/3rds of the dam. The main drain is located about 52 feet upstream from the downstream toe. There are a number of laterals that lead from the main drain to the rock filled toe or the edge of the embankment toe. During the reconstruction of the outlet works, the main drain was uncovered, but it was very hard to distinguish it from the embankment material.

Seepage has been observed exiting from a number of locations along the rock toe, which flows, into the seepage pond located below the dam. No estimate could be made of the past flow volume. In comparing past photos of the seepage area, the flow appears to increase when the reservoir’s pool elevation increases and decrease when the reservoir pool elevation decreases.

A filter drain was placed along the downstream 28 feet of the conduit during the outlet reconstruction. The filter consists of "select" pipe drain bedding gravel encased in a filter fabric. The filter drain exits into the outlet-stilling basin. There has been no observable flow from this drain since reconstruction was completed in 1985.

SEEPAGE

Right Abutment: Several seepage areas have been observed exiting from the rock outcrop along the south side of the pond located at the toe of the dam. The seepage flow appears to be passing through the bedrock formation which is laminated sandstone, and exiting below the right abutment embankment contact. At the embankment contact, free water has not been observed but is evidenced by the saturated soils and heavy vegetation. No flow measurements have been made, however total flow is estimated in the 2 to 3 gpm range.

Old Spillway: A similar condition exists below the old spillway area on the right abutment. No standing water has been observed in this area, but the soil is moist with green vegetation indicating that water is present. The seepage exits at a location where the bedrock is exposed about 150 to 300 feet below the spillway area.

Neither of these seepage conditions have apparently saturated the embankment materials nor is there evidence that they have significantly affected the foundation integrity.

Dam Embankment: Seepage water has been observed exiting from a number of locations along the rock toe drain. The seepage flows into the pond located about 100 feet downstream from the dam. No indication of sediment moving with the water has been observed.

Measuring the discharge from the toe drain with weirs or some other measuring device would be difficult due to the flat gradient between the exit location and the pond. Also, the pond receives water from the outlet, because the outlet canal flows through part of the pond.

Monitoring Wells

As part of the Outlet Conduit Investigation in 1982, a single open standpipe observation well was installed in the area of the outlet conduit along the downstream shoulder of the dam. This observation well was removed during the reconstruction of the outlet conduit in 1985 and not replaced.

In 2004 the SWP installed 5 wells each with deep and shallow piezometers. Three of the wells are located on the crest of the dam. Two more monitoring wells were drilled at the toe of the dam (See Figure 3). Each monitoring well has two standpipes. Soil profiles of the drill holes and well details are shown in appendix C. Levels in monitoring wells should be monitored monthly from May through September during years when the reservoir fills. However, the reservoir has not filled since the piezometers were installed. A minimum monitoring schedule during low water years shall include Spring and Fall, and monitoring on periodic site visits by the dam operator and SWP staff. Increased monitoring to monthly or more frequently will be determined by DNRC Lewistown Regional Office, and Helena Regional Office SWPB staff. Monitoring well measurements are primarily performed by the dam operator. The wells may also be measured by DNRC Lewistown Regional Office, and Helena Regional Office SWPB staff.

MAINTENANCE

The association is responsible for routine maintenance of the project. In addition, the SWPB may identify items that need maintenance or repair during the annual inspection.

ROUTINE MAINTENANCE

To project the dam and keep it in good working order, the dam operator during regular visits to the dam will watch for and identify any potential maintenance requirements. As soon as a need is identified, the dam operator needs to schedule and perform the routing maintenance.

Items that may need occasional attention include, but are not limited to:

1. *Lubrication of gate-operating mechanism.*
2. *Debris or silt plugging the outlet channel or spillway.*
Accumulated debris that could affect the operation of these appurtenances should be removed at once, with all debris removed at least annually.
3. *Erosion gullies on embankment.* Development of erosion gullies should be checked immediately. Gullies should be filled, compacted, and seeded. Particular attention should be paid to the abutment contact areas and the downstream faces.
4. *Four wheel tracks:* Four-wheel driving on the downstream faces should not be allowed. If four-wheel drive tracks become evident, a fence should be placed along the base of the dam embankment.
5. *Rodent damage.* Rodent should be removed or destroyed and any burrow holes should be filled immediately.
6. *Upstream slope riprap.* The upstream face riprap will be observed annually, but may occasionally need repairs because of high water or wave action.

7. *Vegetative cover on downstream slopes.* Good vegetative cover will be maintained, but large brush or any trees will be removed.
8. *Noxious weeds.* Noxious weeds on and around the dam embankment and dikes, and around the reservoir, should be sprayed at least on an annual basis.
9. *Cleaning outlet wall tops.* Outlet wall tops should be clear of any dirt, rocks, grass, brush, and any overhanging vegetation.
10. *Concrete repair.* Any damage or spalling of the concrete on the gate tower or outlet walls should be repaired.
11. *Dam crest.* The dam crest should be graded periodically to remove ruts and restore grade.

ANNUAL MAINTENANCE

The SWPB conducts annual inspections of the Yellow Water Dam and reservoir. During these inspections, any items requiring annual maintenance will be identified and recorded. Items that may need annual maintenance include the outlet works, operating gate, riprap, and roads.

After the inspection, the SWPB sends the association a Dam Safety Inspection Report and a Maintenance Report. The reports identify items that need maintenance and provide a schedule of when the maintenance tasks need to be completed. The association is responsible for performing the maintenance items within the times specified.

The dam operator or association members may perform the maintenance items. However, major repairs will likely to be handled by a contractor. The SWPB may assist in contracting for repairs and may supervise the repair work.

RECORD KEEPING

The SWPB maintains records, including photographs, of all inspections and maintenance requirements. Records are also maintained of the reservoir storage volume. Anyone who wants to review these records may do so in the SWPB's office at the Department of Natural Resources and Conservation in Helena.

The dam operator keeps records of the reservoir elevation, seepage observation or measurements, and any unusual conditions. These records may be reviewed at the dam operator's home

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Phillips, Kenneth P.E. September 2007. Yellow Water Impoundment Structure Five Year Comprehensive Inspection Report. Prepared for the State of Montana (DNRC).

Taylor, Arthur D. P.E. October 2002. Engineer's Inspection Supplement for the Yellowwater Dam. Prepared for the State of Montana (DNRC).

APPENDICES

APPENDIX A
RATING CURVES AND TABLES

TABLE 1. ACTIVE STORAGE IN ACRE-FEET**YELLOW WATER RESERVOIR**

| Elevation | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 3094 | | | | | | 0 | 2 | 3 | 5 | 7 |
| 3095 | 8 | 10 | 12 | 14 | 15 | 17 | 19 | 21 | 22 | 24 |
| 3096 | 26 | 27 | 29 | 31 | 33 | 34 | 36 | 38 | 39 | 41 |
| 3097 | 43 | 45 | 46 | 48 | 50 | 52 | 53 | 55 | 57 | 58 |
| 3098 | 60 | 62 | 64 | 65 | 67 | 71 | 76 | 80 | 84 | 88 |
| 3099 | 93 | 97 | 101 | 105 | 110 | 114 | 118 | 122 | 127 | 131 |
| 3100 | 135 | 139 | 144 | 148 | 152 | 156 | 161 | 165 | 169 | 173 |
| 3101 | 178 | 182 | 186 | 190 | 195 | 199 | 203 | 207 | 212 | 216 |
| 3102 | 220 | 229 | 238 | 247 | 257 | 266 | 275 | 284 | 293 | 302 |
| 3103 | 312 | 321 | 330 | 339 | 348 | 357 | 366 | 376 | 385 | 394 |
| 3104 | 403 | 412 | 421 | 430 | 440 | 449 | 458 | 467 | 476 | 485 |
| 3105 | 495 | 504 | 513 | 522 | 531 | 540 | 549 | 559 | 568 | 577 |
| 3106 | 586 | 603 | 620 | 638 | 655 | 672 | 689 | 706 | 723 | 741 |
| 3107 | 758 | 775 | 792 | 809 | 826 | 844 | 861 | 878 | 895 | 912 |
| 3108 | 930 | 947 | 964 | 981 | 998 | 1,015 | 1,033 | 1,050 | 1,067 | 1,084 |
| 3109 | 1,101 | 1,118 | 1,136 | 1,153 | 1,170 | 1,187 | 1,204 | 1,221 | 1,239 | 1,256 |
| 3110 | 1,273 | 1,299 | 1,324 | 1,350 | 1,375 | 1,401 | 1,426 | 1,452 | 1,477 | 1,503 |
| 3111 | 1,528 | 1,554 | 1,579 | 1,605 | 1,630 | 1,656 | 1,681 | 1,707 | 1,732 | 1,758 |
| 3112 | 1,783 | 1,809 | 1,834 | 1,860 | 1,885 | 1,911 | 1,936 | 1,962 | 1,987 | 2,013 |
| 3113 | 2,038 | 2,064 | 2,089 | 2,115 | 2,140 | 2,166 | 2,191 | 2,217 | 2,242 | 2,268 |
| 3114 | 2,293 | 2,326 | 2,358 | 2,391 | 2,423 | 2,456 | 2,488 | 2,521 | 2,553 | 2,586 |
| 3115 | 2,618 | 2,651 | 2,683 | 2,716 | 2,748 | 2,781 | 2,813 | 2,846 | 2,878 | 2,911 |
| 3116 | 2,943 | 2,976 | 3,008 | 3,041 | 3,073 | 3,106 | 3,138 | 3,171 | 3,203 | 3,236 |
| 3117 | 3,268 | 3,301 | 3,333 | 3,366 | 3,398 | 3,431 | 3,463 | 3,496 | 3,528 | 3,561 |
| 3118 | 3,593 | 3,633 | 3,674 | 3,714 | 3,754 | 3,794 | 3,835 | 3,875 | 3,915 | 3,955 |
| 3119 | 3,996 | 4,036 | 4,076 | 4,116 | 4,157 | 4,197 | 4,237 | 4,277 | 4,318 | 4,358 |
| 3120 | 4,398 | 4,438 | 4,479 | 4,519 | 4,559 | 4,599 | 4,640 | 4,680 | 4,720 | 4,760 |
| 3121 | 4,801 | 4,841 | 4,881 | 4,921 | 4,962 | 5,002 | 5,042 | 5,082 | 5,123 | 5,163 |
| 3122 | 5,203 | 5,253 | 5,302 | 5,352 | 5,402 | 5,452 | 5,501 | 5,551 | 5,601 | 5,651 |
| 3123 | 5,700 | 5,750 | 5,800 | 5,850 | 5,899 | 5,949 | 5,999 | 6,049 | 6,098 | 6,148 |
| 3124 | 6,198 | 6,248 | 6,297 | 6,347 | 6,397 | 6,447 | 6,496 | 6,546 | 6,596 | 6,646 |
| 3125 | 6,695 | 6,745 | 6,795 | 6,845 | 6,894 | 6,944 | 6,994 | 7,044 | 7,093 | 7,143 |

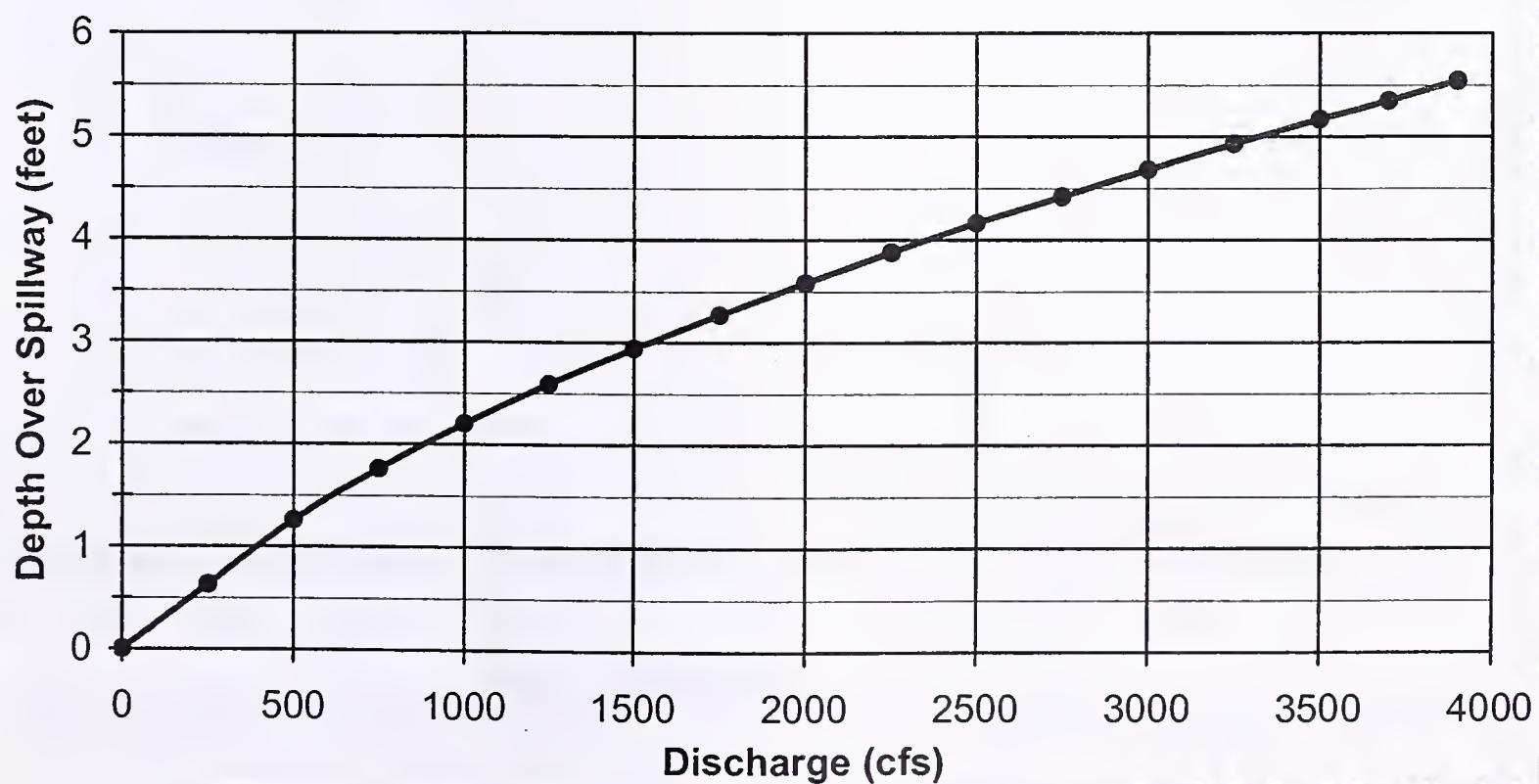
Spillway crest elevation 3118.6 (old datum 992.6)

Top of tower elevation 3125.0 (old datum 999.0)

NOTE: Storage table based on 1984 aerial photography and mapping of the reservoir.

TABLE 2. SPILLWAY DISCHARGE**YELLOW WATER DAM**

| Depth Over Crest (feet) | Elevation (feet) | Discharge (cfs) |
|-------------------------------|---------------------|--------------------|
| 0 | 3118.3 | 0 |
| 0.63 | 3118.93 | 250 |
| 1.26 | 3119.56 | 500 |
| 1.76 | 3120.06 | 750 |
| 2.2 | 3120.5 | 1000 |
| 2.59 | 3120.89 | 1250 |
| 2.94 | 3121.24 | 1500 |
| 3.27 | 3121.57 | 1750 |
| 3.58 | 3121.88 | 2000 |
| 3.88 | 3122.18 | 2250 |
| 4.16 | 3122.46 | 2500 |
| 4.42 | 3122.72 | 2750 |
| 4.68 | 3122.98 | 3000 |
| 4.93 | 3123.23 | 3250 |
| 5.17 | 3123.47 | 3500 |
| 5.35 | 3123.65 | 3700 |
| 5.54 | 3123.84 | 3900 |

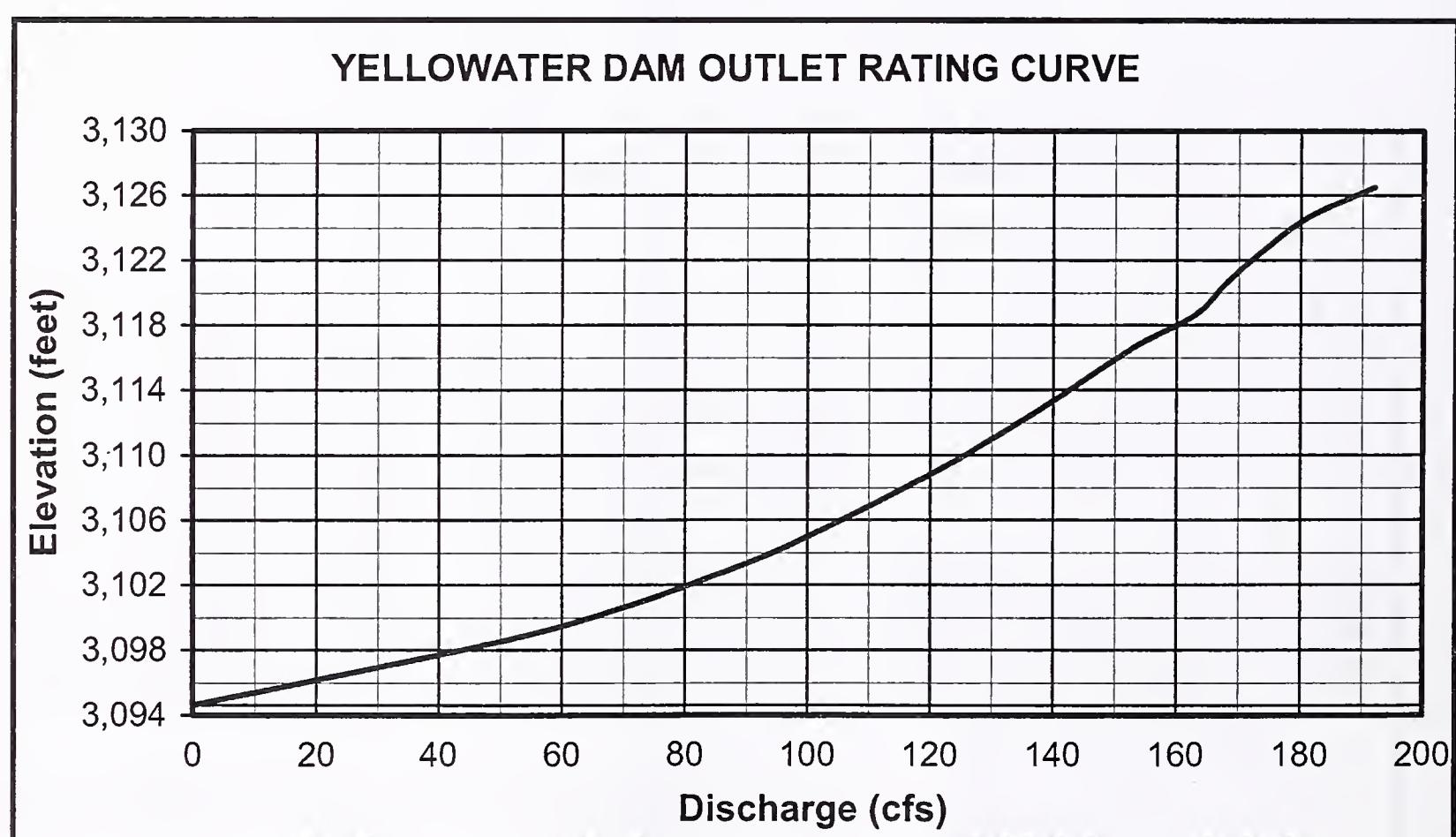
YELLOW WATER DAM SPILLWAY RATING CURVE

Note: Data From 2007 Yellow Water Five Year Inspection by Kenneth Phillips P.E.

TABLE 3. OUTLET DISCHARGE
YELLOW WATER RESERVOIR

| Reservoir Elevation (feet) | Discharge** (cfs) | Comment |
|----------------------------------|----------------------|-------------------|
| 3,094.6 | 0 | |
| 3,098.6 | 51 | |
| 3,100.6 | 70 | |
| 3,102.6 | 85 | |
| 3,104.6 | 98 | |
| 3,108.6 | 119 | |
| 3,112.6 | 137 | |
| 3,116.6 | 153 | |
| 3,118.6 | 163 | Spillway Crest |
| 3,120.6 | 168 | |
| 3,122.6 | 174 | |
| 3,124.6 | 181 | |
| 3,126.5 | 192 | Maximum Dam Crest |

**Discharge assumes operating gate is in fully open position.



Note: Data from the Corps of Engineers Phase 1 Inspection Report (1980).

APPENDIX B
INSPECTION CHECKLIST

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
DAM SAFETY INSPECTION REPORT

NAME OF DAM
DATE INSPECTED

INVENTORY NO. _____
HAZARD CATEGORY _____
TYPE OF DAM _____
YEAR BUILT _____

OWNER _____
OPERATOR _____
STREAM _____
DRAINAGE AREA _____

Reservoir Storage Status

| | Water Surface Elevation (feet) | Storage (acre-feet) |
|-----------------------------|-----------------------------------|------------------------|
| At time of inspection | _____ | _____ |
| At spillway crest | _____ | _____ |
| At min. dam crest elevation | _____ | _____ |

| ITEM | YES | NO | REMARKS |
|------|-----|----|---------|
|------|-----|----|---------|

1. EMBANKMENT

A. Crest -- Height= Length= Width=

| | | | |
|-----------------------------|--|--|--|
| (1) Any visual settlements? | | | |
| (2) Any misalignments? | | | |
| (3) Any cracking? | | | |
| (4) Any traffic damage? | | | |
| (5) Other? | | | |

| ITEM | YES | NO | REMARKS |
|------|-----|----|---------|
|------|-----|----|---------|

1. EMBANKMENT (continued)

B. Upstream Face -- Slope=

| | | | |
|--|--|--|--|
| (1) Any erosion? | | | |
| (2) Any longitudinal cracks? | | | |
| (3) Any transverse cracks? | | | |
| (4) Is riprap protection adequate? | | | |
| (5) Any stone deterioration? | | | |
| (6) Any visual settlement, slumps, sloughing, depressions or bulges? | | | |
| (7) Adequate grass cover? | | | |
| (8) Debris on the dam face? | | | |
| (9) Other? | | | |

C. Downstream Face--Slope= 1V on 2H

| | | | |
|--|--|--|--|
| (1) Any erosion? | | | |
| (2) Any longitudinal cracks? | | | |
| (3) Any transverse cracks? | | | |
| (4) Any visual settlement, slumps, sloughing, depressions or bulges? | | | |
| (5) Is the toe drain dry? | | | |
| (6) Are the relief wells flowing? | | | |
| (7) Any boils at the toe? | | | |
| (8) Any seepage areas? | | | |
| (9) Any traffic or animal damage? | | | |
| (10) Any burrowing animals? | | | |
| (11) Adequate grass cover? | | | |
| (12) Other? | | | |

D. Amount and Type of Vegetation on the Dam

| |
|--|
| |
|--|

| ITEM | YES | NO | REMARKS |
|------|-----|----|---------|
|------|-----|----|---------|

2. ABUTMENT CONTACTS

| | | | |
|--------------------------------------|--|--|--|
| A) Any erosion? | | | |
| B) Any visual differential movement? | | | |
| C) Any cracks? | | | |
| D) Any seepage present? | | | |
| E) Other? | | | |

3. OUTLET WORKS

A. Intake Structure -- Size=

| | | | |
|--------------------------------|--|--|--|
| (1) Any settlement? | | | |
| (2) Any tilting? | | | |
| (3) Do concrete surfaces show: | | | |
| a. Spalling? | | | |
| b. Cracking? | | | |
| c. Erosion? | | | |
| d. Exposed reinforcement? | | | |
| (4) Do joints show: | | | |
| a. Displacement or offset? | | | |
| b. Loss of joint material? | | | |
| c. Leakage? | | | |
| (5) Metal appurtenances: | | | |
| a. Any corrosion present? | | | |
| b. Any breakage present? | | | |
| (6) Trash rack? | | | |
| a. Condition? | | | |
| b. Anchor system secure? | | | |
| (7) Other? | | | |

| ITEM | YES | NO | REMARKS |
|------|-----|----|---------|
|------|-----|----|---------|

3. OUTLET WORKS (continued)

B. Conduit -- Type =

| | | | |
|-----------------------------------|--|--|--|
| (1) Do concrete surfaces show: NA | | | |
| a. Spalling? | | | |
| b. Cracking? | | | |
| c. Erosion? | | | |
| d. Exposed reinforcement? | | | |
| (2) Do joints show: | | | |
| a. Displacement or offset? | | | |
| b. Loss of joint material? | | | |
| c. Leakage? | | | |
| (3) Is the conduit metal? | | | |
| a. Any corrosion present? | | | |
| b. Protective coatings adequate? | | | |
| (4) Is the conduit misaligned? | | | |
| (5) Any calcium deposits? | | | |
| (6) Other? | | | |

C. Gates and Tower

| | | | |
|---|------------|--|--|
| (1) Gates: | | | |
| a. Size: Operating: | Emergency: | | |
| b. Type: Operating: | Emergency: | | |
| (2) Controls operational? | | | |
| (3) Controls lubricated? | | | |
| (4) Operational problems? | | | |
| (5) Leakage around gates? | | | |
| (6) Gate seals in good condition? | | | |
| (7) Any cavitation damage? If so, describe? | | | |
| (8) Describe air vent-size and condition. | | | |

| ITEM | YES | NO | REMARKS |
|------|-----|----|---------|
|------|-----|----|---------|

3. OUTLET WORKS (continued)

C. Gates and Tower (continued)

| | | | |
|--|--|--|--|
| (9) Is there a jet pump? | | | |
| a. Is it operational? | | | |
| b. Leakage? | | | |
| (10) Is the tower dry? wet? | | | |
| (11) Any seepage in the tower? | | | |
| (12) Tower in good condition? | | | |
| (13) Any safety problems? | | | |
| (14) Ladder in good condition? | | | |
| (15) Gate house in good condition? | | | |
| (16) Emergency plan completed for the dam? | | | |
| a. Posted in the gatehouse? | | | |
| (17) Other? | | | |

D. Stilling Basin

| | | | |
|----------------------------------|--|--|--|
| (1) Do concrete surfaces show: | | | |
| a. Spalling? | | | |
| b. Cracking? | | | |
| c. Erosion? | | | |
| d. Exposed reinforcement? | | | |
| (2) Do joints show: | | | |
| a. Displacement or offset? | | | |
| b. Loss of joint material? | | | |
| c. Leakage? | | | |
| (3) Do energy dissipaters show: | | | |
| a. Signs of deterioration? | | | |
| b. Are they covered with debris? | | | |
| (4) Other? | | | |

| ITEM | YES | NO | REMARKS |
|------|-----|----|---------|
|------|-----|----|---------|

3. OUTLET WORKS (continued)

E. Downstream Channel

| | | | |
|-----------------------------|--|--|--|
| (1) Is the channel: | | | |
| a. Eroding or back cutting? | | | |
| b. Sloughing? | | | |
| c. Obstructed? | | | |
| (2) Is released water: | | | |
| a. Undercutting the outlet? | | | |
| b. Eroding the embankment? | | | |
| (3) Other? | | | |

4. SPILLWAY

A. Description

| | | | |
|--|--|--|--|
| (1) Location? | | | |
| (2) Type of Spillway? | | | |
| (3) Size of Spillway? | | | |
| (4) Spillway lining? | | | |
| (5) Is there a weir? | | | |
| (6) Is the spillway in good condition? | | | |
| (7) Any drains? | | | |
| a. Describe the condition of drains. | | | |

B. Does spillway show:

| | | | |
|--|--|--|--|
| (1) Any cracking concrete? | | | |
| (2) Any spalling concrete? | | | |
| (3) Any exposed reinforcement in the concrete? | | | |
| (4) Any erosion? | | | |

| ITEM | YES | NO | REMARKS |
|------|-----|----|---------|
|------|-----|----|---------|

4. SPILLWAY (continued)

B. Does spillway show: (continued)

| | | | |
|------------------------------------|--|--|--|
| (5) Any slope sloughing? | | | |
| (6) Any obstructions? | | | |
| (7) Displacement or offset joints? | | | |
| (8) Loss of joint material? | | | |
| (9) Leakage at the joints? | | | |
| (10) Other? | | | |

C. Do the energy dissipaters show:

| | | | |
|-----------------------------------|--|--|--|
| (1) Signs of deterioration? | | | |
| (2) Any cracking? | | | |
| (3) Any spalling? | | | |
| (4) Any exposed reinforcement? | | | |
| (5) Are they covered with debris? | | | |
| (6) Other? | | | |

D. Has release water:

| | | | |
|------------------------------------|--|--|--|
| (1) Eroded the embankment? | | | |
| (2) Undercut the outlet? | | | |
| (3) Eroded the downstream channel? | | | |
| (4) Other? | | | |

E. Emergency Spillway

| | | | |
|-------------------------------------|--|--|--------------------|
| (1) Is there an emergency spillway? | | | (If YES, describe) |
| | | | |

| ITEM | YES | NO | REMARKS |
|------|-----|----|---------|
|------|-----|----|---------|

5. RESERVOIR CONTROL

| | | | |
|-----------------------------------|--|--|--|
| A) Recent upstream development? | | | |
| B) Recent downstream development? | | | |
| C) Slides in reservoir area? | | | |
| D) Change in reservoir operation? | | | |
| E) Large impoundment upstream? | | | |
| F) Any debris in the reservoir? | | | |
| G) Other? | | | |

6. INSTRUMENTATION

| | | | |
|---|--|--|--|
| A) List type(s) of instrumentation:.. | | | |
| B) In good condition? | | | |
| C) Read periodically? | | | |
| D) Is data available? | | | |
| E) Include all data gathered since last report. | | | |

7. DOWNSTREAM CONDITION

A. Downstream Land Use.

| |
|--|
| |
|--|

This dam was inspected by:

Additional comments and recommendations.

APPENDIX C
MONITORING WELL LOGS



SOIL LOG OF BOREHOLE NO: DH1

(Page 1 of 2)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : YELLOWATER
DATE STARTED : 10/8/2004
DATE COMPLETED : 10/9/2004
DRILL COMPANY : Ruen Drilling
DRILLER : Jim Erdman

DRILL RIG : BK-66
DRILLING METHOD : Hollow-stem Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Bob Arrington
APPROVED BY : Brian Grant

| Depth in Feet | Surf. Elev. 3126.0 | Sample Interval | SAMPLER TYPE | | USCS | GRAPHIC | Sampler Type | Blow Count | Adjusted Blow Counts (blows/foot) | Inches Recovered Inches Driven | % Recovery | Piston Penetrometer (tons/square foot) | REMARKS |
|---------------------|--------------------------|-----------------|--|-----------------------------|------|---------|--------------|--------------|--------------------------------------|-----------------------------------|------------|---|--|
| | | | SS Split spoon | SL Split Spoon Brass Liners | | | | | | | | | |
| 0 | 3126 | | 0 to 1' ROAD BASE gravelly, dry | | GP | | | | | | | | |
| 5 | 3121 | | 2 to 42' LEAN CLAY, with sand, stiff, brown, slightly moist to moist, med. plasticity, w/ small amount of organics | | | | SS | 4 6 7 | 13 | 17/18 | 84% | | |
| 10 | 3116 | | | | | | SL | 4 7 12 | 16 | 18/18 | 100% | 4.0 | At 10 to 11.5' Finer #200 = 85% Dry unit wt. = 102 pcf, m = 18.1% LL=33%, PL=15%, PI=18% TV=2.3 tsf |
| 15 | 3111 | | | | | | CL | 3 5 6 | 11 | 17/18 | 94% | | |
| 20 | 3106 | | Slightly moist | | | | SL | 5 7 12 | 16 | 18/18 | 100% | 4.5 | At 20 to 21.5' Finer #200 = 80% Dry unit wt. = 112.6 pcf, m = 17.3% LL=34%, PL=14%, PI=20% Pinhole=ND Tv=2.3 tsf |
| 25 | 3101 | | | | | | ST | | | 24/24 | 100% | | At 25 to 27' Finer #200 = 95% LL=38%, PL=16%, PI=22% Dry unit wt. = 106.8 pcf, m = 19.3% CU test: C=3.87psi, phi=15.1 C=1.97psi, phi=27.9 |
| 30 | | | | | | | | | | | | | |

Hammer 140 lbs 30" drop hydraulic
Standard Spoon OD 2.0" ID 1.5"
Brass Liner Spoon OD 2.5" ID 2.0"



SOIL LOG OF BOREHOLE NO: DH1

(Page 2 of 2)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : YELLOWATER
DATE STARTED : 10/8/2004
DATE COMPLETED : 10/9/2004
DRILL COMPANY : Ruen Drilling
DRILLER : Jim Erdman

DRILL RIG : 3K-66
DRILLING METHOD : Hollow-stem Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Bob Arlington
APPROVED BY : Brian Grant

| Depth in Feet | Surf. Elev. 3126.0 | Sample Interval | SAMPLER TYPE | | USCS | GRAPHIC | Sampler Type | Blow Count | Adjusted Blow Counts (blows/ft) | Inches Recovered Inches Driven | % Recovery | Pocket Penetrometer (tons/square foot) | REMARKS |
|---------------------|--------------------------|-----------------|--|----|------|---------|--------------|------------------|------------------------------------|-----------------------------------|------------|---|--|
| | | | SS | SL | | | | | | | | | |
| 30 | 3096 | | | | | | SL | 4 5 6 7 | 11 | 18/18 | 100% | 0.75 | TV=0.6 tsf |
| 35 | 3091 | | | | | | SS | 4 6 8 | 12 | 18/18 | 100% | | At 35 to 36.5' Finer #200 = 81% LL=37%, PL=16%, PI=21% |
| 40 | 3086 | | At 40 to 41.5' clay, augered fairly easily, decomposed shale | | | | SS | 6 11 21 | 32 | 18/18 | 100% | | |
| 45 | 3081 | | At 42 to 55' SHALE, decomposed shale from 42' to 45', more competent from 45' to bottom of hole (55'); shale is black, with thin laminae | | | | SL | 10 21 30 | 45 | 18/18 | 100% | | standing water at 45' |
| 50 | 3076 | | | | | | SH | | | | | | |
| 55 | 3071 | | 55' BOTTOM OF HOLE | | | | SS | 25 50+ | | 10.5/10.5 | 100% | | |

Hammer 140 lbs 30" drop hydraulic
Standard Spoon OD 2.0" ID 1.5"
Brass Liner Spoon OD 2.5" ID 2.0"

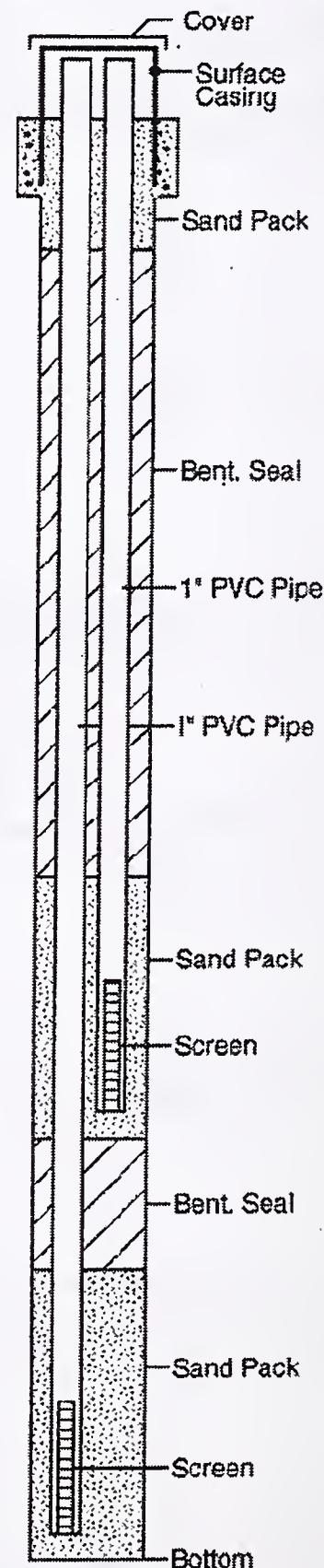


WELL COMPLETION LOG NO: DH1

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| | | | |
|--|--------------------------|--|---|
| MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION P.O. Box 201601 Helena, MT 59601-1601 (406) 444-6646 | | RESERVOIR : Yellowwater DATE STARTED : 10/8/2004 DATE COMPLETED : 10/9/2004 DRILL COMPANY : Ruch Drilling DRILLER : Jim Erhman | DRILL RIG : BK-66 DRILLING METHOD : Hollow Stem Auger GAMPLING METHOD : Split Spoon LOGGED BY : Bob Arrington APPROVED BY : Brian Grant |
| Depth In Feet | Surf. Elev. 3126.0 | Well Construction Information | DESCRIPTION |
| 0 | 3126 | WELL CONSTRUCTION Date Compl. : 10/8/2004 Hole Diameter : 6 inch DNRC Rep. : Bob Arrington | 0 to 5 SAND |
| 5 | 3121 | STANDPIPE Material : PVC pipe Diameter : 1 inch Joints : screwed Bottom Cap : glued | 5 to 29 BENTONITE |
| 10 | 3116 | WELL SCREEN Material : PVC pipe Diameter : 1 inch Length : 5 feet Opening : .02 inch | |
| 15 | 3111 | SAND PACK Material : Colorado Silica 10/20 | |
| 20 | 3106 | ANNULUS Material : 3/8 inch Bentonite | |
| 25 | 3101 | WELL COVER Size : 4" x 4" square Length : 5 feet | |
| 30 | 3096 | NOTES: Surface Elev: 3126.0 feet | 29 to 39 SAND |
| 35 | 3091 | DH1D TOP Elev: 3128.3 feet (estimate) | 33 to 38 DH1S SCREEN |
| 40 | 3066 | DH1S TOP Elev: 3128.4 feet (estimate) | 39 to 44 BENTONITE |
| 45 | 3081 | Top of Cover Elev: 3128.5 feet (estimate) | 42 BEDROCK -- Shale |
| 50 | 3076 | Nothing: ?? | 44 to 55 SAND |
| 55 | 3071 | Easting: ?? | 49 to 54 DH1D SCREEN |
| 60 | | Surveyed By: Date Surveyed: | 55 BOTTOM OF HOLE |

Well1: DH-1D
Well2: DH-1S





SOIL LOG OF BOREHOLE NO: DH2

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : YELLOWATER
DATE STARTED : 10/8/2004
DATE COMPLETED : 10/9/2004
DRILL COMPANY : Ruen Drilling
DRILLER : Jim Eidman

DRILL RIG : BK-66
DRILLING METHOD : Hollow-stem Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Bob Arrington
APPROVED BY : Brian Grant

| Depth in Feet | Surf. Elev. 3089.0 | Sample Interval | SAMPLER TYPE | USCS | GRAPHIC | Sampler Type | Blow Count | Adjusted Blow Counts (blows/foot) | Inches Recovered | Inches Driven | % Recovery | Pocket Penetrometer (tons/square foot) | REMARKS |
|---------------------|--------------------------|-------------------------------------|---|------|---------|--------------|----------------|--------------------------------------|------------------|---------------|------------|---|--|
| | | | SS Split spoon SL Split Spoon Brass Liners ST Shelby Tube | | | | | | | | | | |
| 0 | 3089 | | 0 to 8.5' CLAYEY SAND, brown, moist to wet, organics | | | | | | | | | | |
| 5 | 3084 | <input checked="" type="checkbox"/> | Water surface at 4' | SC | | SS | 2 1 2 | 3 | 5/18 | 28% | | | At 5 to 6.5' clayey sand Finer #200 = 26%, gravel = 30% LL=22%, PL=14%, PI=8% |
| 10 | 3079 | <input checked="" type="checkbox"/> | At 8.5 to 15' CLAYEY GRAVEL, (decomposed shale), dark gray-brown, moist to wet | | GC | SL | 4 8 9 | 14 | 18/18 | 100% | | | |
| 15 | 3074 | <input checked="" type="checkbox"/> | At 15 to 40' SHALE, w/ thin laminae, dark gray. 15' to 18' crumbles easily, 18' to 40' competent and fresher | | | SS | 13 25 34 | 59 | 18/18 | 100% | | | At 15 to 16.5' Cored 15 to 20', recovery = 83%, RQD = 48% |
| 20 | 3069 | | | SH | | | | | | | | | Cored 25 to 30', recovery = 100%, RQD = 80%, 2-4 frax/ft |
| 25 | 3064 | | | | | | | | | | | | Cored 25 to 30', recovery = 90%, RQD = 70%, 8 frax/5ft |
| 30 | | | At 30 to 31.5', numerous fractures | | | | | | | | | | |

Hammer 140 lbs 30' drop hydraulic
Standard Spoon OD 2.0" ID 1.5"
Brass Liner Spoon OD 2.5" ID 2.0"



SOIL LOG OF BOREHOLE NO: DH2

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MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : YELLOWWATER
DATE STARTED : 10/8/2004
DATE COMPLETED : 10/9/2004
DRILL COMPANY : Ruen Drilling
DRILLER : Jim Erdman

DRILL RIG : BK-66
DRILLING METHOD : Hollow-stem Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Bob Arrington
APPROVED BY : Brian Grant

| Depth in Feet | Surf. Elev. 3089.0 | Sample Interval | SAMPLER TYPE SS Split spoon SL Split Spoon Brass Liners ST Shelby Tube | DESCRIPTION | | USCS | GRAPHIC | Sampler Type | Blow Count | Adjusted Blow Counts (blows/foot) | Inches Recovered Inches Driven | % Recovery | Pocket Penetrometer (tons/square foot) | REMARKS |
|---------------------|--------------------------|-----------------|---|-------------|---------|------------|--------------------------------------|-----------------------------------|------------|---|-----------------------------------|------------|---|---|
| | | | | USCS | GRAPHIC | Blow Count | Adjusted Blow Counts (blows/foot) | Inches Recovered Inches Driven | % Recovery | Pocket Penetrometer (tons/square foot) | | | | |
| 30 | 3059 | | | | | | | | | | | | | Cored 30 to 35', dark gray shale, recovery = 100%, RQD = 77%, |
| 35 | 3054 | | | | SH | | | | | | | | | Cored 35 to 40', recovery = 97%, RQD = 87%, 8 frax/5ft |
| 40 | 3049 | | 40' BOTTOM OF HOLE | | | | | | | | | | | |
| 45 | 3044 | | | | | | | | | | | | | |
| 50 | 3039 | | | | | | | | | | | | | |
| 55 | 3034 | | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | | | |

Hammer 140 lbs 30" drop hydraulic
Standard Spoon OD 2.0" ID 1.5"
Brass Liner Spoon OD 2.5" ID 2.0"



WELL COMPLETION LOG NO: DH2

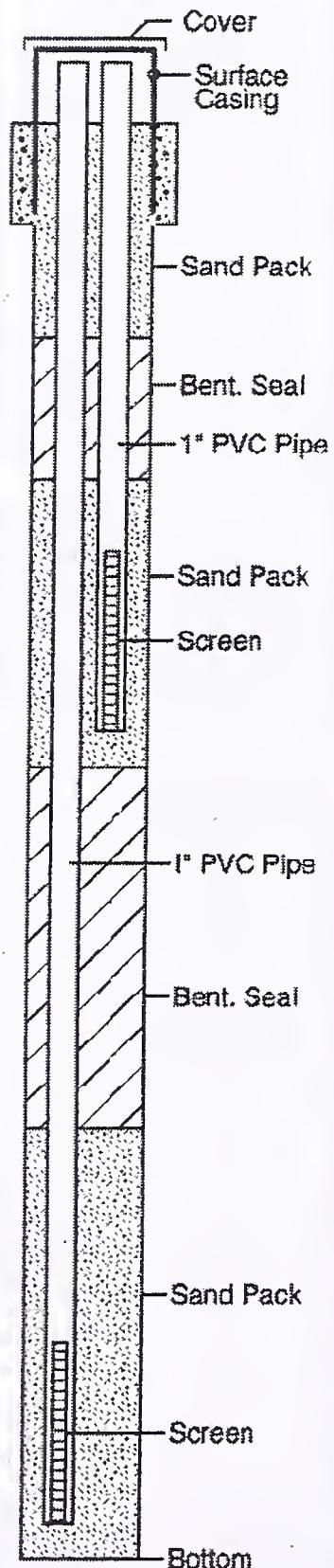
(Page 1 of 1)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

| | | | |
|----------------|-----------------|-----------------|--------------------------|
| RESERVOIR | : Yellowwater | DRILL RIG | : BK-66 |
| DATE STARTED | : 10/7/2004 | DRILLING METHOD | : Hollow Stem Auger/Core |
| DATE COMPLETED | : 10/7/2004 | SAMPLING METHOD | : Split Spoon |
| DRILL COMPANY | : Ruen Drilling | LOGGED BY | : Bob Arrington |
| DRILLER | : Jim Erhman | APPROVED BY | : Brian Grant |

| Depth In Feet | Surf. Elev. 3089.0 | Well Construction Information | DESCRIPTION | Depth In Feet |
|---------------------|--------------------------|--|---------------------------------------|---------------------|
| 0 | 3089 | WELL CONSTRUCTION Date Compl. : 10/7/2004 Hole Diameter : 8 inch DNRC Rep. : Bob Arrington | 0 to 6 SAND | 0 |
| 5 | 3084 | STANDPIPE Material : PVC pipe Diameter : 1 inch Joints : screwed Bottom Cap : glued | 6 to 10 BENTONITE | 5 |
| 10 | 3079 | WELL SCREEN Material : PVC pipe Diameter : 1 inch Length : 5 feet Opening : .02 inch | 10 to 18 SAND | 10 |
| 15 | 3074 | SAND PACK Material : Colorado Silica 10/20 | 12 to 17 DH2S SCREEN | 15 |
| 20 | 3069 | ANNULUS Material : 3/8 inch Bentonite | 18 to 28 BENTONITE | 20 |
| 25 | 3064 | WELL COVER Size : 4" x 4" square Length : 5 feet | 18 BEDROCK -- Shale | 25 |
| 30 | 3059 | NOTES: Surface Elev: 3089.0 feet (estimate) DH2D TOP Elev: 3091.3 feet (estimate) DH2S TOP Elev: 3091.4 feet (estimate) Top of Cover Elev: 3091.5 feet (estimate) Northing: ?? Easting: ?? Surveyed By: Date Surveyed: | 28 to 40 SAND 34 to 39 DH2D SCREEN | 30 |
| 40 | 3049 | | 40 BOTTOM OF HOLE | 40 |

Well1: DH-2D
Well2: DH-2S





SOIL LOG OF BOREHOLE NO: DH3

(Page 1 of 2)

| | | | | |
|--|--------------------------|---|---|--|
| MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION P.O. Box 201601 Helena, MT 59601-1601 (406) 444-6646 | | | RESERVOIR : YELLOWWATER | DRILL RIG : BK-66 |
| DATE STARTED : 10/9/2004 | | | DRILLING METHOD : Hollow-stem Auger/Core | |
| DATE COMPLETED : 10/9/2004 | | | SAMPLING METHOD : Split Spoon | |
| DRILL COMPANY : Ruen Drilling | | | LOGGED BY : Craig Stiles | |
| DRILLER : Jim Erdman | | | APPROVED BY : Brian Grant | |
| Depth in Feet | Surf. Elev. 3106.0 | Sample Interval | SAMPLER TYPE | REMARKS |
| | | | SS Split spoon SL Split Spoon Brass Liners ST Shelby Tube HQ-NW Core Barrel | |
| | | DESCRIPTION | USCS GRAPHIC Sampler Type Blow Count Adjusted Blow Counts (blows/foot) Inches Recovered Inches Driven % Recovery Pocket Penetrometer (tons/square foot) | |
| 0 | 3106 | 0 to 4' Silty Sand | SM | |
| 5 | 3101 | 4 to 22.5' SANDSTONE, fine-grained, gray-brown, w/ thin dark gray shale interlayers | SS | 20 13 27 40 16/18 89% |
| 10 | 3096 | At 9 to 10.5' ss laminae are harder and shaly layers are darker gray to almost black | SS | 14 19 29 48 18/18 100% |
| 15 | 3091 | | | At 12' switched to core from casing advance drilling; 12 to 15' recovery = 100%, RQD = 14%, 4 frax per ft, bedding dip varies from nearly horizontal to 20deg |
| 20 | 3086 | | | Cored from 15 to 20' recovery = 90%, RQD = 18% Frax/ft = >6, nearly horizontal laminae |
| 25 | 3081 | 22.5 to 45' SHALE, dark gray, thin laminae, w/ scattered thin alternating layers of lt. gray, fine-grained sandstone | SH | Cored from 20 to 25' Recovery = 100%, RQD = 47% Frax / ft = 6, upper 2.5' mostly ss, lower 2.5' mostly shale |
| 30 | | | | Cored from 25 to 30' laminated shale; recovery 100%, RQD = 60%, Frax/ft = 5 |

Hammer 140 lbs 30" drop hydraulic
 Standard Spoon OD 2.0" ID 1.5"
 Brass Liner Spoon OD 2.5" ID 2.0"



SOIL LOG OF BOREHOLE NO: DH3

(Page 2 of 2)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6846

| | | | |
|----------------|-----------------|-----------------|--------------------------|
| RESERVOIR | : YELLOWATER | DRILL RIG | : BK-66 |
| DATE STARTED | : 10/9/2004 | DRILLING METHOD | : Hollow-stem Auger/Core |
| DATE COMPLETED | : 10/9/2004 | SAMPLING METHOD | : Split Spoon |
| DRILL COMPANY | : Ruen Drilling | LOGGED BY | : Craig Stiles |
| DRILLER | : Jim Erdman | APPROVED BY | : Brian Grant |

Hammer 140 lbs 30° drop hydraulic
 Standard Spoon OD 2.0" ID 1.5"
 Brass Liner Spoon OD 2.5" ID 2.0"



WELL COMPLETION LOG NO: DH3

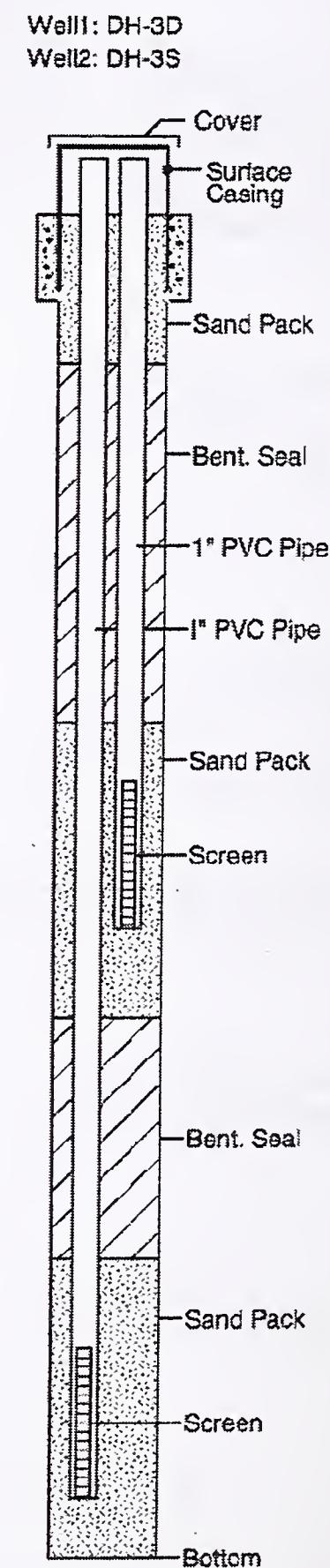
(Page 1 of 1)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Yellowwater
DATE STARTED : 10/9/2004
DATE COMPLETED : 10/9/2004
DRILL COMPANY : Ruen Drilling
DRILLER : Jim Erhman

DRILL RIG : BK-66
DRILLING METHOD : HW Case Advance/Core
SAMPLING METHOD : Split Spoon
LOGGED BY : Craig Stiles
APPROVED BY : Brian Grant

| Depth In Feet | Surf. Elev. 3110.0 | Well Construction Information | DESCRIPTION | Depth In Feet |
|---------------------|--------------------------|---|----------------------|---------------------|
| 0 - 3110 | | WELL CONSTRUCTION Date Compl. : 10/9/2004 Hole Diameter : 4.25 inch DNRC Rep. : Craig Stiles | 0 to 5 SAND | 0 |
| 5 - 3105 | | STANDPIPE Material : PVC pipe Diameter : 1 inch Joints : screwed Bottom Cap : glued | 5 to 17 BENTONITE | 5 |
| 10 - 3100 | | WELL SCREEN Material : PVC pipe Diameter : 1 inch Length : 5 feet Opening : .02 inch | | 10 |
| 15 - 3095 | | SAND PACK Material : Colorado Silica 10/20 | 17 to 27 SAND | 15 |
| 20 - 3090 | | ANNULUS Material : 3/8 inch Bentonite | 19 to 24 DH3S SCREEN | 20 |
| 25 - 3085 | | WELL COVER Size : 4" x 4" square Length : 5 foot | 26 Bedrock -- Shale | 25 |
| 30 - 3080 | | NOTES: Surface Elev: 3110.0 feet (estimate) | 27 to 35 BENTONITE | 30 |
| 35 - 3075 | | DH3D TOP Elev: 3112.3 feet (estimate) | | 35 |
| 40 - 3070 | | DH3S TOP Elev: 3112.4 feet (estimate) | 35 to 45 SAND | 40 |
| 45 - 3065 | | Top of Cover Elev: 3112.5 feet (estimate) | 38 to 43 DH3D SCREEN | 45 |
| 50 | | Northing: ?? Easting: ?? Surveyed By: Date Surveyed: | | 50 |





SOIL LOG OF BOREHOLE NO: DH4

(Page 1 of 2)

| | | | | | | |
|--|-------------------------|-------------------------------------|---|---|--|--|
| MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION P.O. Box 201601 Helena, MT 59601-1601 (406) 444-6646 | | | RESERVOIR : YELLOWWATER | DRILL RIG : BK-66 | | |
| DATE STARTED : 10/10/2004 | | | DRILLING METHOD : Hollow-stem Auger | | | |
| DATE COMPLETED : 10/10/2004 | | | SAMPLING METHOD : Split Spoon | | | |
| DRILL COMPANY : Ruen Drilling | | | LOGGED BY : Craig Stiles | | | |
| DRILLER : Jim Erdman | | | APPROVED BY : Brian Grant | | | |
| Depth in Fee: | Sur. Elev. 3126.0 | Sample Interval | SAMPLER TYPE SS Split spoon SL Split Spoon Brass Liners ST Shelby Tube | USCS GRAPHIC Sampler Type Blow Count Adjusted Blow Counts (blows/foot) Inches Recovered Inches Driven % Recovery Pocket Penetrometer (tons/square foot) | REMARKS | |
| 0 | 3126 | | 0 to 2.5' ROAD BASE, gravelly, dry | GP | | |
| 5 | 3121 | <input checked="" type="checkbox"/> | 2.5 to 47.5' LEAN CLAY At 5 to 6.5' brown, med. plasticity, some organics | SS | 3 6 5 11 16/18 83% | |
| 10 | 3116 | <input checked="" type="checkbox"/> | At 1- to 11.5 dark brown, some organics, spoon sank 8" when set in bottom of hole | SL | 3 5 6 9 18/18 100% | 1 At 10 to 11.5 Finer #200 = 90% LL=35%, PL=16%, PI=19% Double Hydr. Dispersion = 11% TV=0.75 |
| 15 | 3111 | <input checked="" type="checkbox"/> | At 15 to 16.5' dark brown, slightly sandy, some organics, stiff | CL | SS 3 7 6 13 18/18 100% | |
| 20 | 3106 | <input checked="" type="checkbox"/> | At 20 to 21.5 black, strongly organic, stiff, some sand | SL | 3 5 6 9 18/18 100% | 1.5 TV=0.6 tsf |
| 25 | 3101 | <input checked="" type="checkbox"/> | At 25 to 26.5 dark brown, stiff, moist, some sand, wet at 26' | SS | 1 3 5 8 18/18 100% | At 25 to 26.5' Finer #200=86% clay=40% LL=32%, PL=16%, PI=16% |
| 30 | | | | | | |

Hammer 140 lbs 30' drop hydraulic
Standard Spoon OD 2.0" ID 1.5"
Brass Liner Spoon OD 2.5" ID 2.0"



SOIL LOG OF BOREHOLE NO: DH4

(Page 2 of 2)

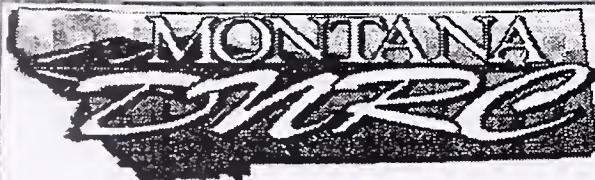
MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : YELLOWATER
DATE STARTED : 10/10/2004
DATE COMPLETED : 10/10/2004
DRILL COMPANY : Ruen Drilling
DRILLER : Jim Erdman

DRILL RIG : BK-65
DRILLING METHOD : Hollow-stem Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Craig Stiles
APPROVED BY : Brian Grant

| Depth in Feet | Surf. Elev. 3126.0 | Sample Interval | SAMPLER TYPE | USCS | GRAPHIC | Sampler Type | Blow Count | Adjusted Blow Counts (blows/foot) | Inches Recovered Inches Driven | % Recovery | Pocket Penetrometer (ton/square foot) | REMARKS |
|---------------------|--------------------------|-----------------|--|------|---------|--------------|------------|--------------------------------------|-----------------------------------|------------|--|---|
| | | | SS Split spoon SL Split Spoon Brass Liners ST Shelby Tube | | | | | | | | | |
| | | | DESCRIPTION | | | | | | | | | |
| 30 | 3096 | | At 30 to 32 Shelby Tube pushed easily for 2' | | | ST | | | 20/24 | 83% | | |
| 35 | 3091 | | At 35 to 36.5 dark brown, moist, some organics, SL settled 6 to 8" when set in ground | CL | | SL | 0 4 8 | 10 | 18/18 | 100% | 1.25 | TV=0.7tsf |
| 40 | 3086 | | At 40 to 41.5 dark brown, stiff, some organics, moist, sampler settled as above | | | SS | 4 8 | 14 | 18/18 | 100% | | At 40 to 41.5' Finer#200=86% LL=35%, PL=15%, PI=20% |
| 45 | 3081 | | At 45 to 46.5' Hit water at 45' dark brown, moist, some organics | | | SL | 4 5 | 9 | 18/18 | 100% | 0.5 | TV=0.5tsf |
| 50 | 3076 | | 47.5 to 53' CLAYEY SAND brown, wet, with some gravel | SC | | SL | 0 3 | 7 | 18/18 | 100% | | At 50 to 51.5' Finer #200 = 42% %gravel=23%, %clay=21% LL=24%, PL=14%, PI=10% Dry Unit Wt = 107.5pcf, m=20.6% |
| 55 | 3071 | | At 53' SHALE BEDROCK dark grey to black, weathered | SH | | | | | | | | |
| | | | 55' BOTTOM OF HOLE | | | SS | 17 50+ | 50+ | 12/12 | 100% | | |

Hammer 140 lbs 30" drop hydraulic
Standard Spoon OD 2.0" ID 1.5"
Brass Liner Spoon OD 2.5" ID 2.0"



WELL COMPLETION LOG NO: DH4

(Page 1 of 1)

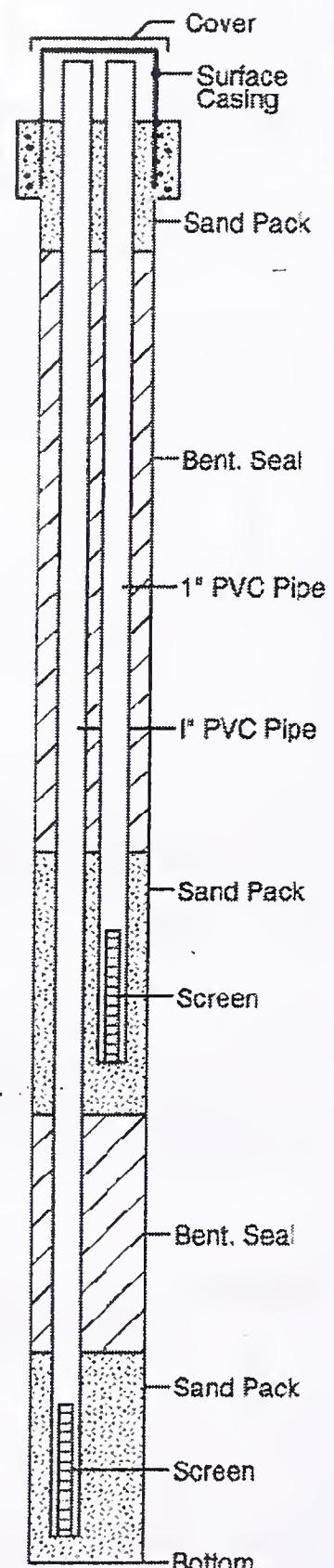
MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : Yellowwater
DATE STARTED : 10/10/2004
DATE COMPLETED : 10/10/2004
DRILL COMPANY : Ruen Drilling
DRILLER : Jim Erhman

DRILL RIG : BK-66
DRILLING METHOD : Hollow Stem Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Craig Stiles
APPROVED BY : Brian Grant

| Depth In Feet | Surf. Elev. 3126.0 | Well Construction Information | DESCRIPTION | Depth In Feet |
|---------------------|--------------------------|---|----------------------|---------------------|
| 0 | 3126 | WELL CONSTRUCTION Date Compl. : 10/10/2004 Hole Diameter : 8 inch DNRC Rep. : Craig Stiles | 0 to 5 SAND | 0 |
| 5 | 3121 | STANDPIPE Material : PVC pipe Diameter : 1 inch Joints : screwed Bottom Cap : glued | 5 to 28 BENTONITE | 5 |
| 10 | 3116 | WELL SCREEN Material : PVC pipe Diameter : 1 inch Length : 5 feet Opening : .02 inch | | 10 |
| 15 | 3111 | SAND PACK Material : Colorado Silica 10/20 | | 15 |
| 20 | 3106 | ANNULUS Material : 3/8 inch Bentonite | | 20 |
| 25 | 3101 | WELL COVER Size : 4" x 4" square Length : 5 feet | 28 to 38 SAND | 25 |
| 30 | 3096 | NOTES: Surface Elev: 3126.0 feet | 31 to 36 DH4S SCREEN | 30 |
| 35 | 3091 | DH4D TOP Elev: 3126.3 feet (estimate) | 38 to 47 BENTONITE | 35 |
| 40 | 3086 | DH4S TOP Elev: 3126.4 feet (estimate) | 47 to 55 SAND | 40 |
| 45 | 3081 | Top of Cover Elev: 3128.5 feet (estimate) | 49 to 54 DH4D SCREEN | 45 |
| 50 | 3076 | Northing: ?? | 55 BOTTOM OF HOLE | 50 |
| 55 | 3071 | Easting: ?? | | 55 |
| 60 | | Surveyed By: Date Surveyed: | | 60 |

Well1: DH-4D
Well2: DH-4S





SOIL LOG OF BOREHOLE NO: DH5

(Page 1 of 2)

MT DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
P.O. Box 201601
Helena, MT 59601-1601
(406) 444-6646

RESERVOIR : YELLOWATER
DATE STARTED : 10/11/2004
DATE COMPLETED : 10/12/2004
DRILL COMPANY : Ruen Drilling
DRILLER : Jim Erdman

DRILL RIG : BK-66
DRILLING METHOD : Hollow-stem Auger
SAMPLING METHOD : Split Spoon
LOGGED BY : Craig Stiles
APPROVED BY : Brian Grant

| Depth in Feet | Surf. Elev. 3126.0 | Sample Interval | SAMPLER TYPE | USCS | GRAPHIC | Sampler Type | Blow Count | Adjusted Blow Counts (blows/foot) | Inches Recovered Inches Driven | % Recovery | Pocket Penetrometer (tons/square foot) | REMARKS |
|---------------------|--------------------------|-----------------|---|------|---------|--------------|---------------|--------------------------------------|-----------------------------------|------------|---|--|
| | | | SS Split spoon SL Split Spoon Brass Liners ST Shelby Tube | | | | | | | | | |
| | | | DESCRIPTION | | | | | | | | | |
| 0 - 3126 | | | 0 to 3' ROAD BASE, gravelly, dry | GP | | | | | | | | |
| 5 - 3121 | | ☒ | 3 to 47' LEAN CLAY At 5 to 6.5' brown, dry | SS | | | 5 6 7 | 13 | 17/18 | 94% | | |
| 10 - 3116 | | ☒ | At 10 to 11.5 brown, some organics | SL | | | 5 14 21 | 29 | 17/18 | 94% | 1 | At 10 to 11.5 Finer #200 = 89% LL=35%, PL=16%, PI=19% Dry Unit Wt. = 103.3 pcf, m=15% TV = 0.2 taf |
| 15 - 3111 | | ☒ | At 15 to 16.5' brown, crumbly, some organics | CL | | SS | 3 6 10 | 16 | 14/18 | 100% | | |
| 20 - 3106 | | ☒ | At 20 to 21.5 black, strongly organic, stiff, some sand | SL | | SS | 3 6 10 | 13 | 18/18 | 100% | 1.25 | At 20 to 21.5 TV = 1.4 taf Finer #200 = 86% Clay = 39% LL=36%, PL=16%, PI=20% Dry Unit Wt. = 101.6 pcf, m = 17.5% |
| 25 - 3101 | | ☒ | At 25 to 26.5 brown, moist, some sand and some organics | GS | | | 2 4 7 | 11 | 15/18 | 83% | | At 25 to 26.5' Finer #200 = 98% LL=44%, PL=16%, PI=28% DS Test: C=0.67 psi, phi=21.2 |
| 30 | | | | | | | | | | | | |

Hammer 140 lbs 30" drop hydraulic
Standard Spoon OD 2.0" ID 1.5"
Brass Liner Spoon OD 2.5" ID 2.0"



SOIL LOG OF BOREHOLE NO: DH5

(Page 2 of 2)

| | | | | | | |
|--|--------------------------|-------------------------------------|--|---|---|--|
| MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION P.O. Box 201601 Helena, MT 59601-1601 (406) 444-6646 | | | RESERVOIR : YELLOWATER | DRILL RIG : BK-66 | | |
| DATE STARTED : 10/11/2004 | | | DRILLING METHOD : Hollow-stem Auger | | | |
| DATE COMPLETED : 10/12/2004 | | | SAMPLING METHOD : Split Spoon | | | |
| DRILL COMPANY : Ruen Drilling | | | LOGGED BY : Craig Stiles | | | |
| DRILLER : Jim Erdman | | | APPROVED BY : Brian Grant | | | |
| Depth in Feet | Surf. Elev. 3126.0 | Sample Interval | SAMPLER TYPE SS Split spoon SL Split Spoon Brass Liners ST Shelby Tube | USCS GRAPHIC Sampler Type Blow Count Adjusted Blow Counts (blows/foot) Inches Recovered Inches Driven % Recovery Pocket Penetrometer (tons/square foot) | REMARKS | |
| 30 | 3096 | <input checked="" type="checkbox"/> | At 30 to 31.5' brown to dk. brown, moist | ST CL SS SL SH | 1 4 8 8 1 3 5 0 12 3 8 17 9 18 29 47 12/12 100% | 2.25 At 30 to 31.5' TV = 1.4 tsf Finer #200 = 87% LL=32%, PL=15%, PI=17% Dry Unit Wt. = 113.2 pcf, m = 18.1% |
| 35 | 3091 | <input checked="" type="checkbox"/> | At 35 to 37' Lean clay, as above | | 22/24 92% | |
| 40 | 3086 | <input checked="" type="checkbox"/> | At 40 to 41.5' mottled coloration consisting of gray clayey blobs mixed with brown sandy organic fill, moist | | 18/18 100% | |
| 45 | 3081 | <input checked="" type="checkbox"/> | At 45 to 46.5' Hit water at 45' Lean clay, moist gray clay with organics | | 18/18 100% | At 45 to 46.5' TV=4 Finer #200 = 62%, Clay = 34% LL=33%, PL=15%, PI=18% Dry Unit Wt. = 106.2 pcf, m = 20.7% |
| 50 | 3076 | <input checked="" type="checkbox"/> | At 47 to 56.5' WEATHERED SHALE BEDROCK, dark gray to black | | 18/18 100% | At 50 to 51.5' Finer #200 = 42% %gravel = 23%, %clay = 21% LL=24%, PL=14%, PI=10% Dry Unit Wt = 107.5 pcf, m=20.6% |
| 55 | 3071 | <input checked="" type="checkbox"/> | 55' BOTTOM OF HOLE At 55 to 56.5' dk. gray to black weathered shale | SS | 9 47 12/12 100% | |
| 60 | | | | | | |

Hammer 140 lbs 30" drop hydraulic
Standard Spoon OD 2.0" ID 1.5"
Brass Liner Spoon OD 2.5" ID 2.0"

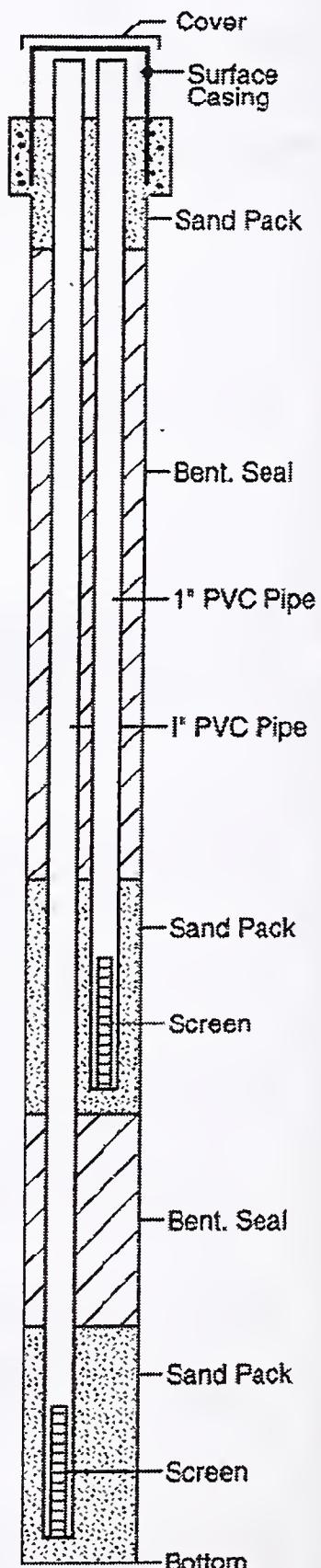


WELL COMPLETION LOG NO: DH5

(Page 1 of 1)

| | | | |
|--|--------------------------|--|--|
| MT DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION P.O. Box 201601 Helena, MT 59601-1601 (406) 444-6646 | | RESERVOIR : Yellowwater DATE STARTED : 10/11/2004 DATE COMPLETED : 10/12/2004 DRILL COMPANY : Ruen Drilling DRILLER : Jim Erhman | DRILL RIG : BK-66 DRILLING METHOD : Hollow Stem Auger SAMPLING METHOD : Split Spoon LOGGED BY : Craig Stiles APPROVED BY : Brian Grant |
| Depth In Feet | Surf. Elev. 3126.0 | Well Construction Information | DESCRIPTION |
| 0 | 3126 | WELL CONSTRUCTION Date Compl. : 10/11/2004 Hole Diameter : 8 inch DNRC Rep. : Craig Stiles | 0 to 5 SAND |
| 5 | 3121 | STANDPIPE Material : PVC pipe Diameter : 1 inch Joints : screwed Bottom Cap : glued | 5 to 29 BENTONITE |
| 10 | 3116 | WELL SCREEN Material : PVC pipe Diameter : 1 inch Length : 5 feet Opening : .02 inch | |
| 15 | 3111 | SAND PACK Material : Colorado Silica 10/20 | |
| 20 | 3106 | ANNULUS Material : 3/8 inch Bentonite | |
| 25 | 3101 | WELL COVER Size : 4" x 4" square Length : 5 feet | |
| 30 | 3096 | NOTES: Surface Elev: 3126.0 feet | 29 to 38 SAND |
| 35 | 3091 | DH5D TOP Elev: 3128.3 feet (estimate) | 32 to 37 DH5S SCREEN |
| | | DH5S TOP Elev: 3128.4 feet (estimate) | |
| 40 | 3086 | Top of Cover Elev: 3128.5 feet (estimate) | 38 to 46 BENTONITE |
| 45 | 3081 | Northing: ?? | |
| | | Easting: ?? | |
| 50 | 3076 | Surveyed By: | |
| | | Date Surveyed: | |
| 55 | 3071 | | 46 to 55 SAND |
| | | | 49 to 54 DH5D SCREEN |
| 60 | | | 55 BOTTOM OF HOLE |

Well1: DH-5D
Well2: DH-5S



APPENDIX C
DISTRUBUTION LIST

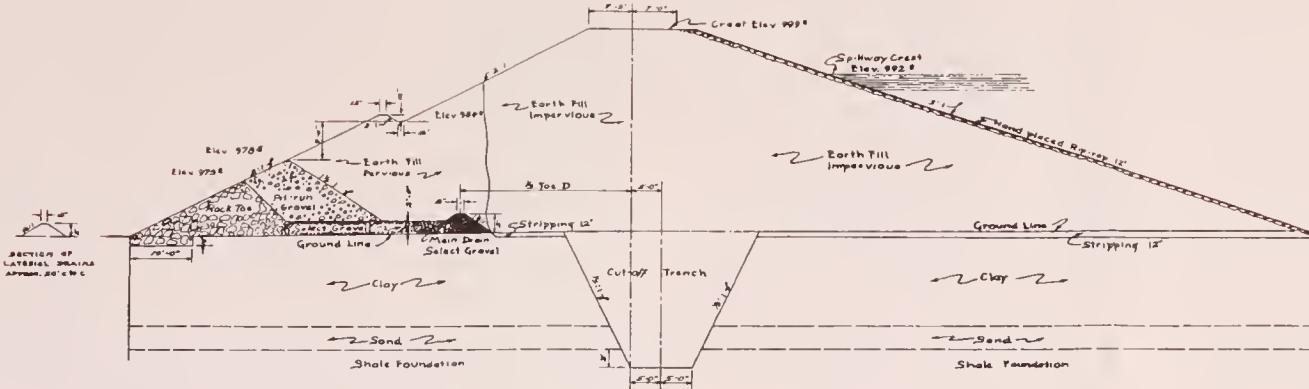
YELLOW WATER DAM O&M DISTRUBUTION LIST

| | <u>Number Of Copies</u> |
|---|-----------------------------|
| 1. State Water Projects Bureau Bureau Chief Project Rehabilitation Section Supervisor Dam Safety Engineer (2) Instrumentation Specialist Dolores Eustice | 7 |
| 2. DNRC Information Services Section | 1 |
| 3. DNRC Lewistown Regional Office | 2 |
| 4. DNRC Dam Safety | 1 |
| 5. Yellow Water Water Users President Secretary/Dam Operator Directors (2) | 4 |
| 6. State Library | 4 |
| 7. Extra | 2 |
| <hr/> TOTAL | 21 |

APPENDIX E

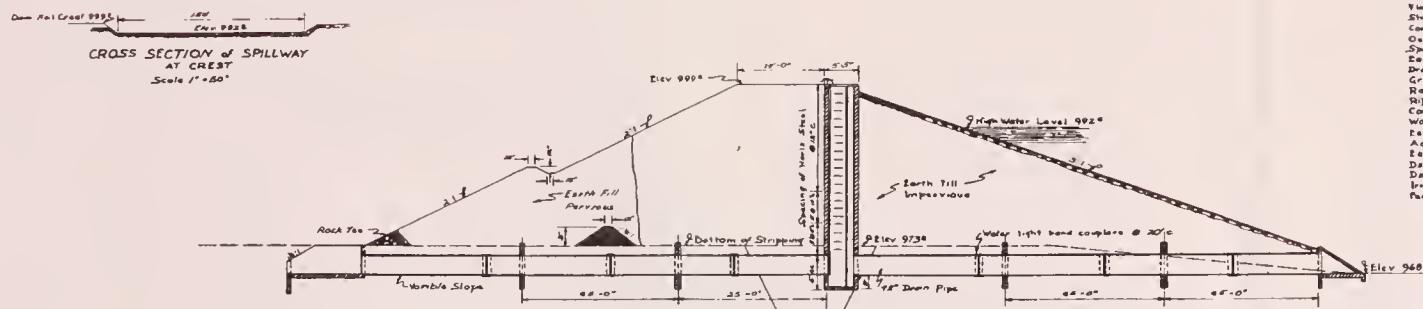
PROJECT DRAWINGS

(NOTE: Reduced project drawings E3 and E4 are design drawings and not "As Builts", and should be used for reference only. The 1985 drawings E5 through E13 are "As-Builts". The SWPB has the full size project drawings.)

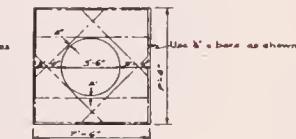


MAXIMUM CROSS SECTION of DAM
 Scale $1'' \times 10'$

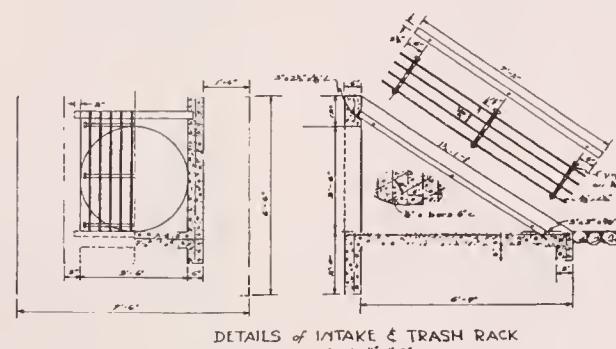
| DESCRIPTION | QUANTITIES |
|--------------------------|-----------------|
| Drainage Area | 55.44 Ac. |
| Storage Area | 4,400 Cu. Yds. |
| Leak Area | 435 Ac. |
| Flow | 1,800 C.F.S. |
| Draining | 9,800 Cu. Yds. |
| Canal Trench Exc. | 15,200 Cu. Yds. |
| Outlet Trench Exc. | 3,600 |
| Slurry Exc. | 3,900 |
| Excavation | 15,000 Cu. Yds. |
| Drainage System - Gravel | 930 |
| Gravel Fill | 9,000 |
| Rock Ties | 3,800 |
| Rock and rock | 4,800 |
| Concrete | 20 |
| Work Started | Mon 12, 1955 |
| Act. Completion | Oct 1, 1956 |
| Act. Cost | \$24,000 Ac. to |
| Donated Material | \$5,000 |
| Unpaid Equipment | \$20,000 |
| Unpaid Labor | 3,000 Ac. |
| Per capita, Benefited | 20 |



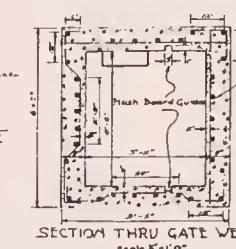
CROSS SECTION of DAM at OUTLET
Scale 1:100



LADDER PITAI

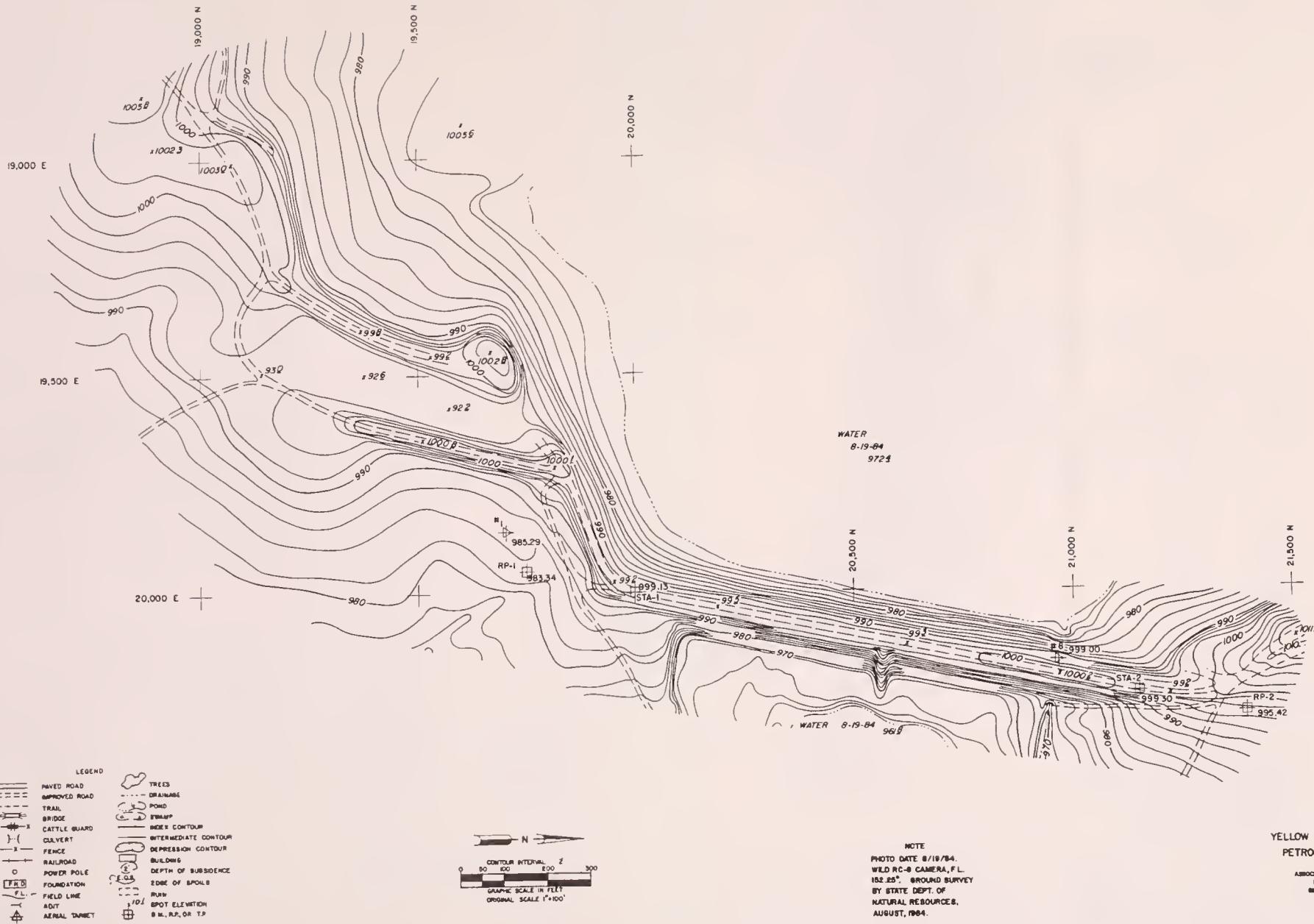


DETAILS of INTAKE & TRASH RACK



SECTION THRU GATE WELL

| | | | | | |
|-----------------------------------|--|---|--|--------------------------------|--|
| WELL | | SECTIONS THRU DAM YELLOW WATER STORAGE PROJECT | | | |
| | | REGION 2018 U.S. DEPARTMENT OF ENERGY | | | |
| | | SOIL CONSERVATION SERVICE | | | |
| | | K. H. MANNET, CHIEF | | | |
| LOCATION: PETROLEUM COUNTY, MONT. | | DEPARTMENT APPROVAL | | | |
| | | TECHNICAL APPROVAL | | | |
| PROPOSED AS OF 1970 | | ----- | | | |
| COMPLETED 1968 J.E.S. | | ENCLOSURE | | DATE 8-27-85 FILE NO. P-448 | |



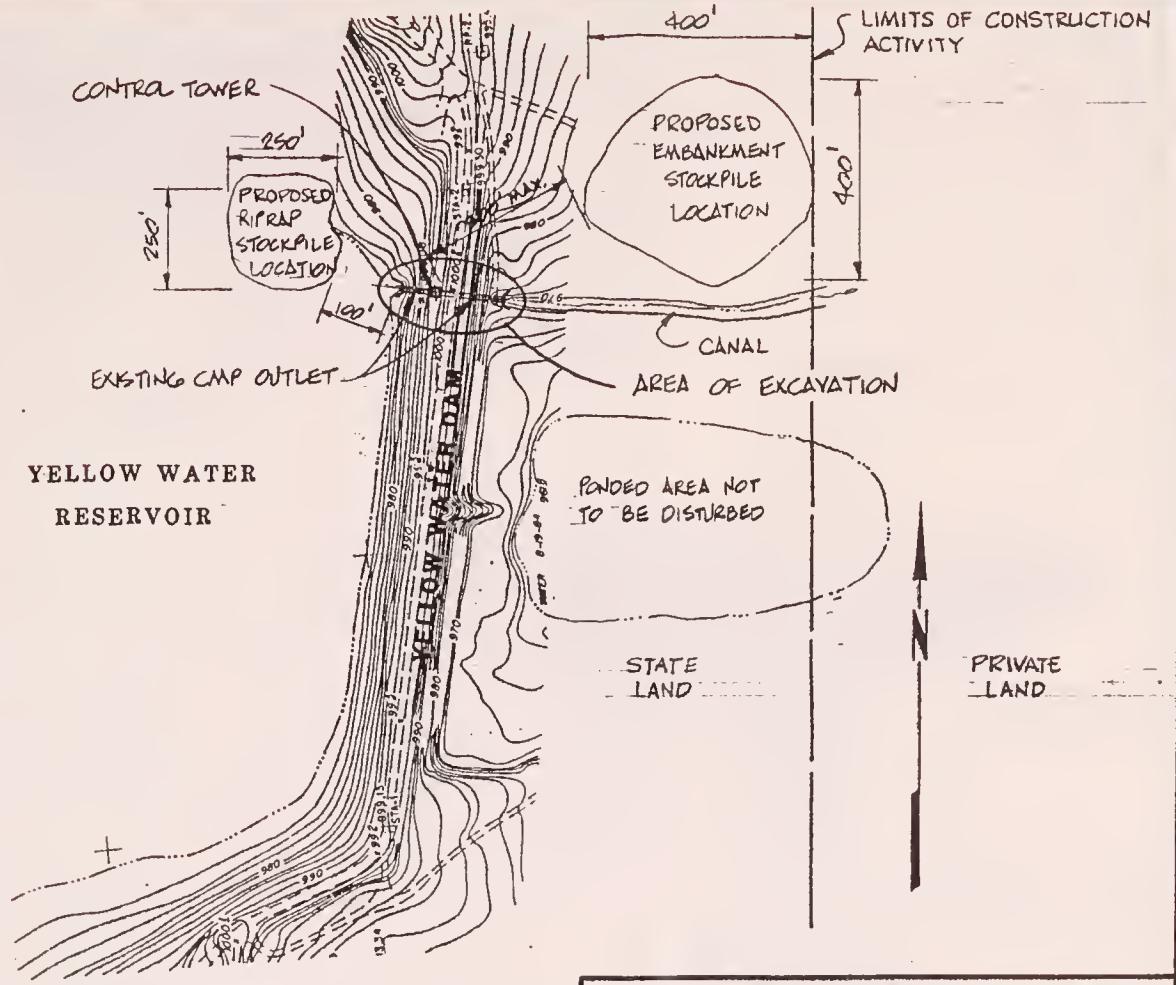
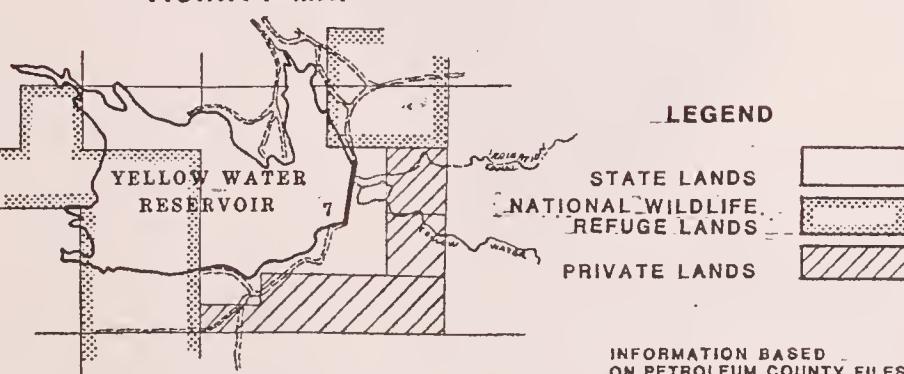
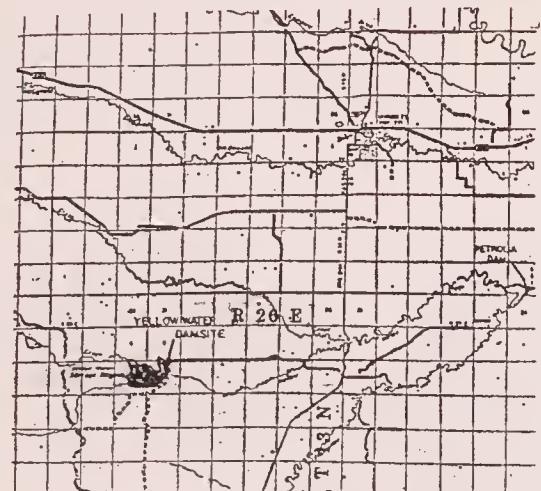
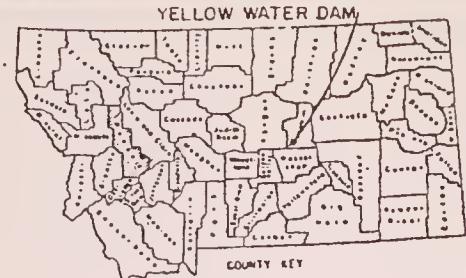
YELLOW WATER RESERVOIR
PETROLEUM, COUNTY

ASSOCIATED SURVEYS
LAND & AERIAL
BILLINGS, MONTANA

Sheet 2 of 2

NOTE
PHOTO DATE 8/19/84.
WILD RC-8 CAMERA, F.L.
152.25°. GROUND SURV.
BY STATE DEPT. OF
NATURAL RESOURCES,
AUGUST, 1984.

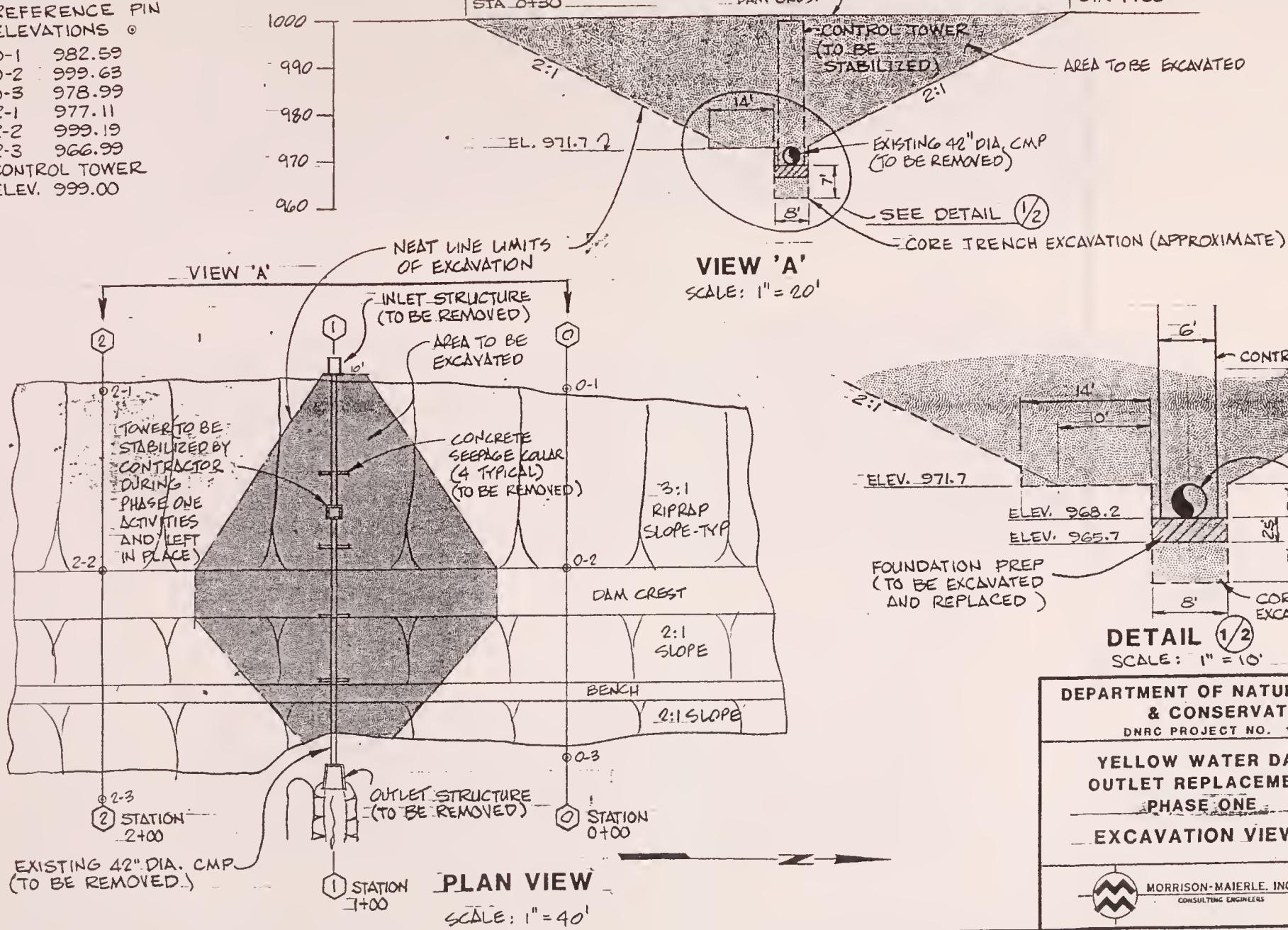




| | |
|--|--|
| DEPARTMENT OF NATURAL RESOURCES & CONSERVATION | |
| DNRC PROJECT NO. 166.001 | |
| YELLOW WATER DAM OUTLET REPLACEMENT | |
| PHASE ONE | |
| LOCATION MAP | |
| DRAWN JMH | |
| DESIGNED PPP | |
| DATE 8-27-85 | |
| PROJECT NO. 1447-012-01 | |
| SHEET NO. 1 | |
| MORRISON-MAIERLE, INC. | |
| CONSULTING ENGINEERS | |

5-166-6

REFERENCE PIN
ELEVATIONS @
0-1 982.59
0-2 999.63
0-3 978.99
2-1 977.11
2-2 999.19
2-3 966.99
CONTROL TOWER
ELEV. 999.00



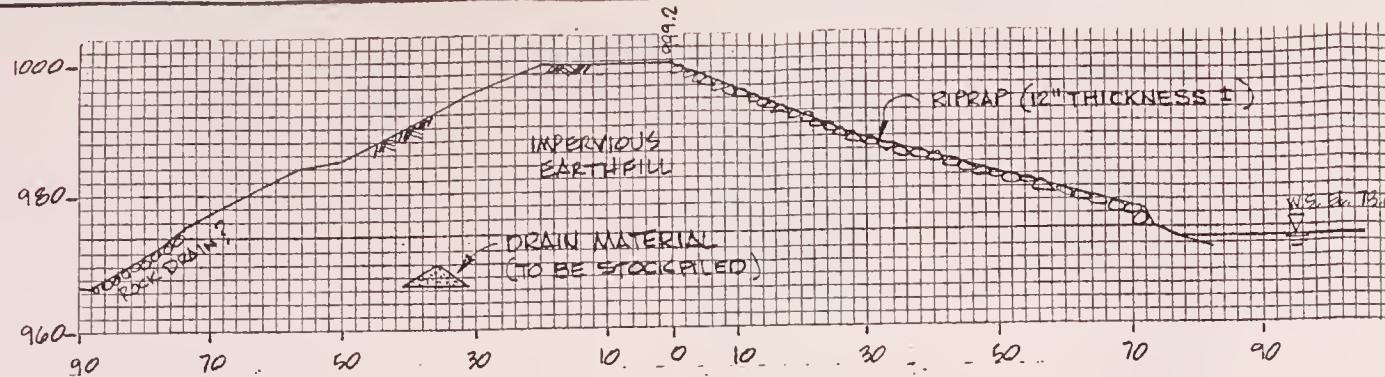
**DEPARTMENT OF NATURAL RESOURCES
& CONSERVATION**
DNRC PROJECT NO. 166.001

**YELLOW WATER DAM
OUTLET REPLACEMENT
PHASE ONE
EXCAVATION VIEWS**

EXCAVATION VIEWS

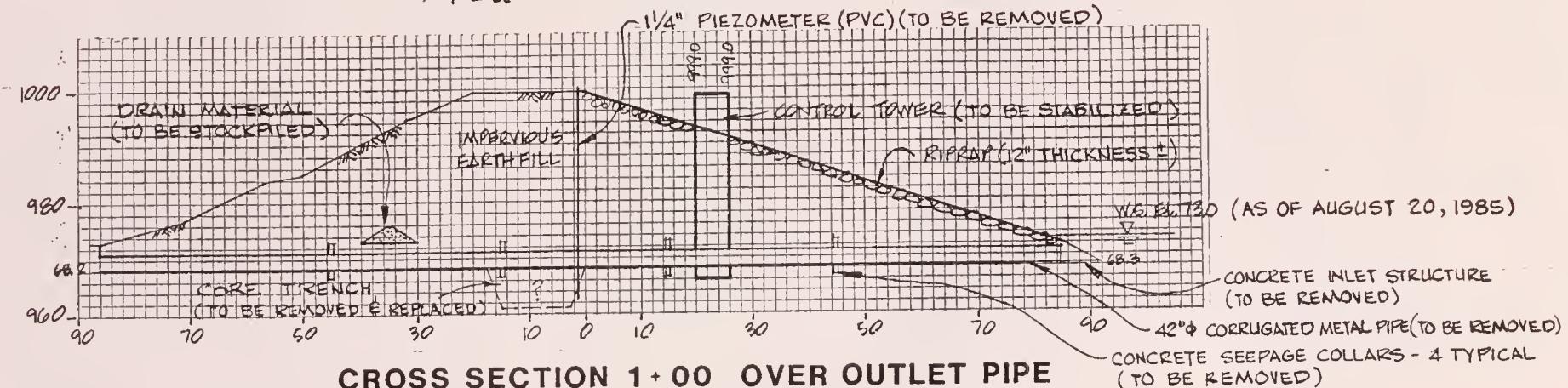
| |
|-------------|
| DRAWN |
| JMH |
| DESIGNED |
| PPP |
| DATE |
| 8-27-85 |
| PROJECT NO. |
| 1447-02-01 |

HEET NO. 2



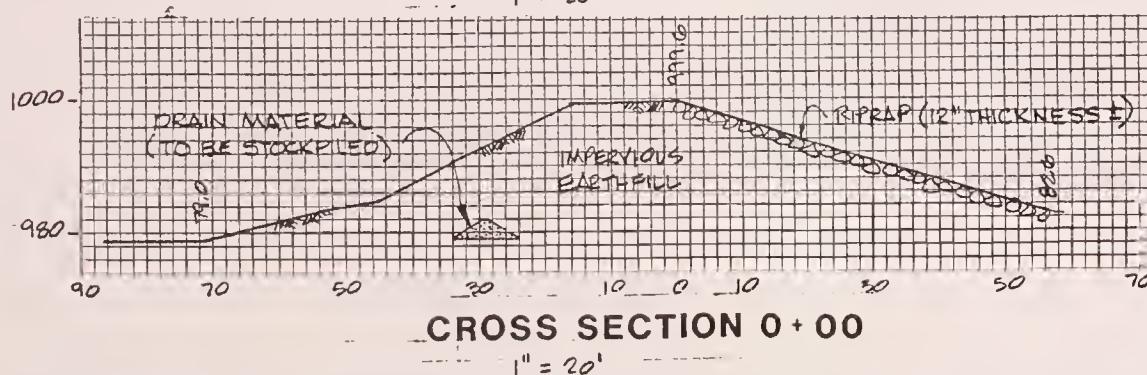
CROSS SECTION 2 + 00

1" = 20'



CROSS SECTION 1 + 00 OVER OUTLET PIPE

1" = 20'



CROSS SECTION 0 + 00

1" = 20'

DEPARTMENT OF NATURAL RESOURCES
& CONSERVATION
DNRC PROJECT NO. 166.001

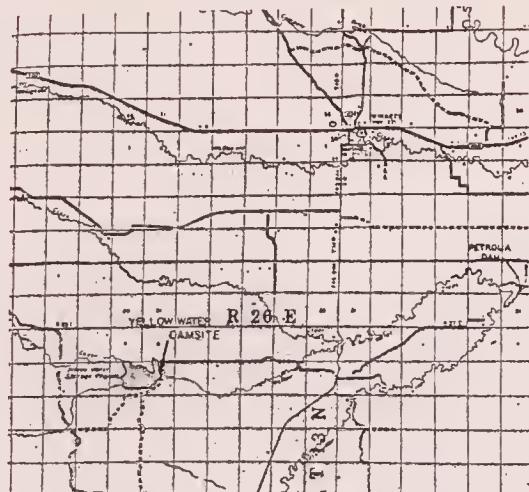
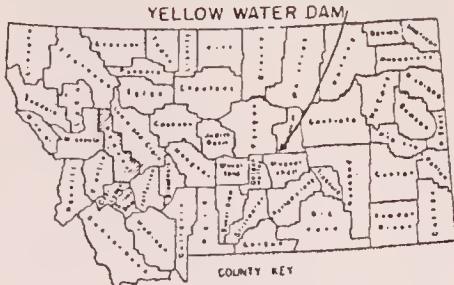
YELLOW WATER DAM
OUTLET REPLACEMENT
PHASE ONE
CROSS SECTIONS



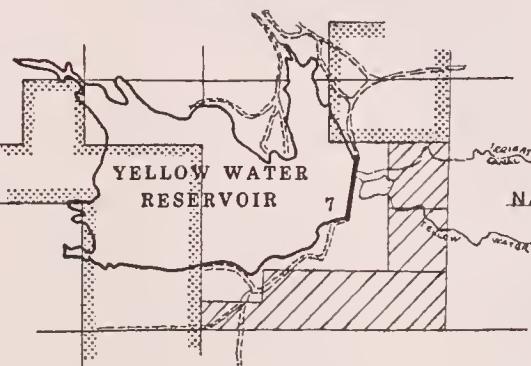
MORRISON-MAIERLE, INC.
CONSULTING ENGINEERS

DRAWN
JMH
DESIGNED
PPP
DATE
3-27-85
PROJECT NO.
1447-02-01
SHEET NO.
3

5-166-8
E7 2007



VICINITY MAP



LAND OWNERSHIP MAP

INFORMATION BASED
ON PETROLEUM COUNTY FILES

POTENTIAL RIPRAP
SOURCE

1.7 MILES

RIPRAP STOCKPILE LOCATION

EMBANKMENT
STOCKPILE

EMBANKMENT
STOCKPILE

LIMITS OF CONSTRUCTION
ACTIVITY

POTENTIAL BORROW SOURCE

CONTROL TOWER

YELLOW WATER
RESERVOIR

CANAL
RECONSTRUCTION AREA

ROCK TOE

PONDED AREA NOT
TO BE DISTURBED

STATE
LAND

PRIVATE
LAND

SITE PLAN

CONTOUR INTERVAL
50 100 150 200
FEET
MAP SCALE IN FEET

DEPARTMENT OF NATURAL RESOURCES
& CONSERVATION
DNRC PROJECT NO. 166.002

YELLOW WATER DAM
OUTLET REPLACEMENT
PHASE TWO
LOCATION MAP

DRAWN
JMH
DESIGNED
PPP
DATE
9-2-05
PROJECT NO.
1447-0001
SHEET NO.



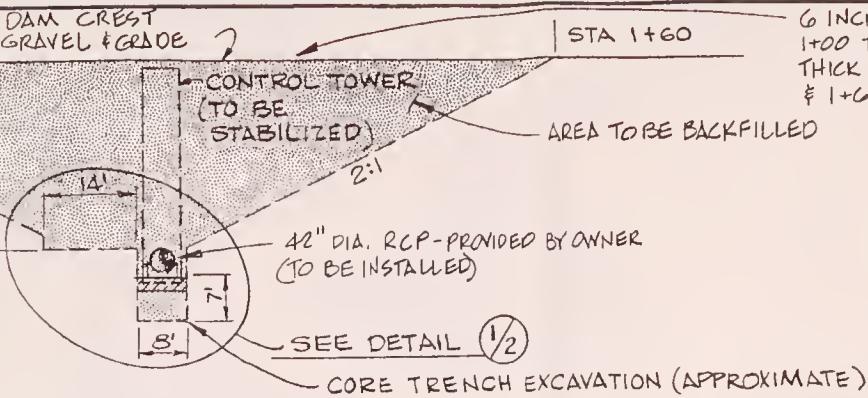
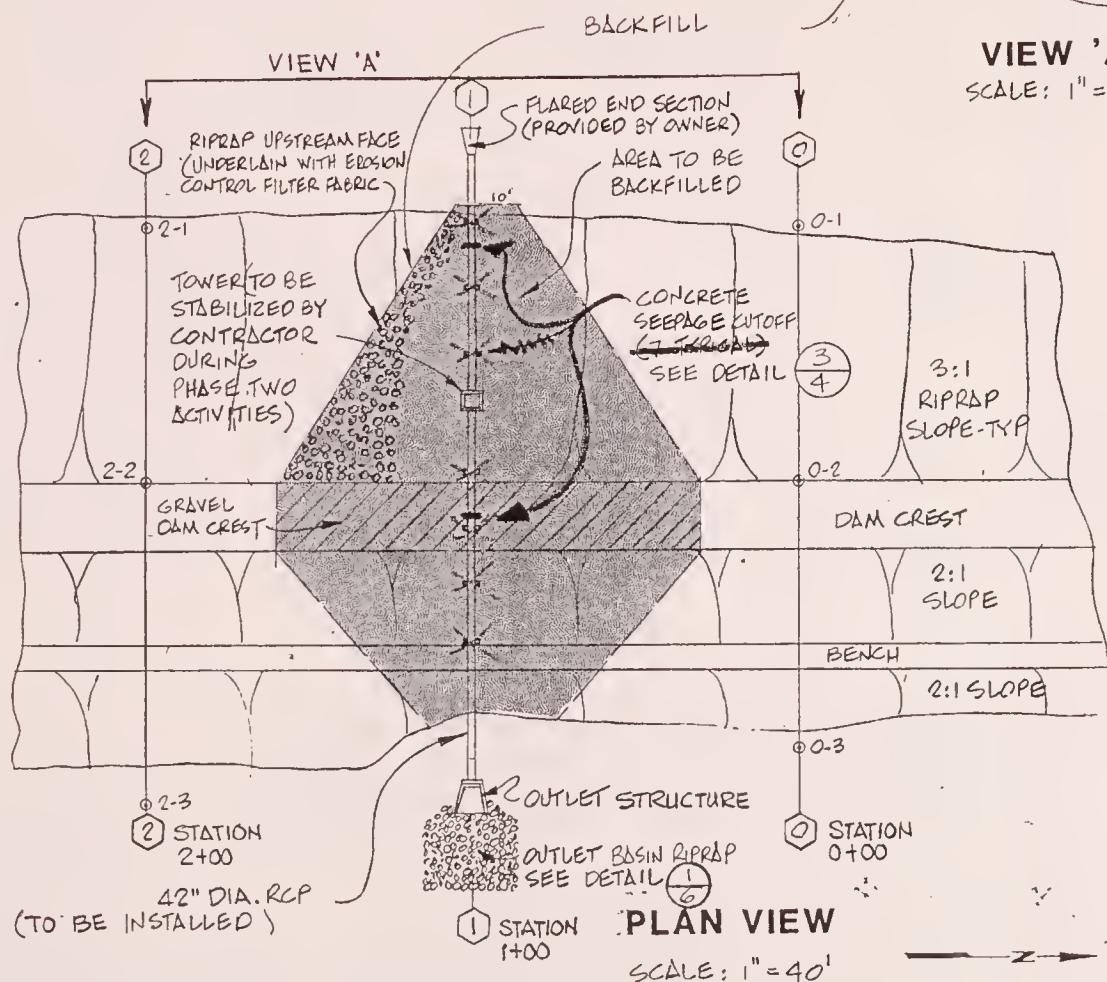
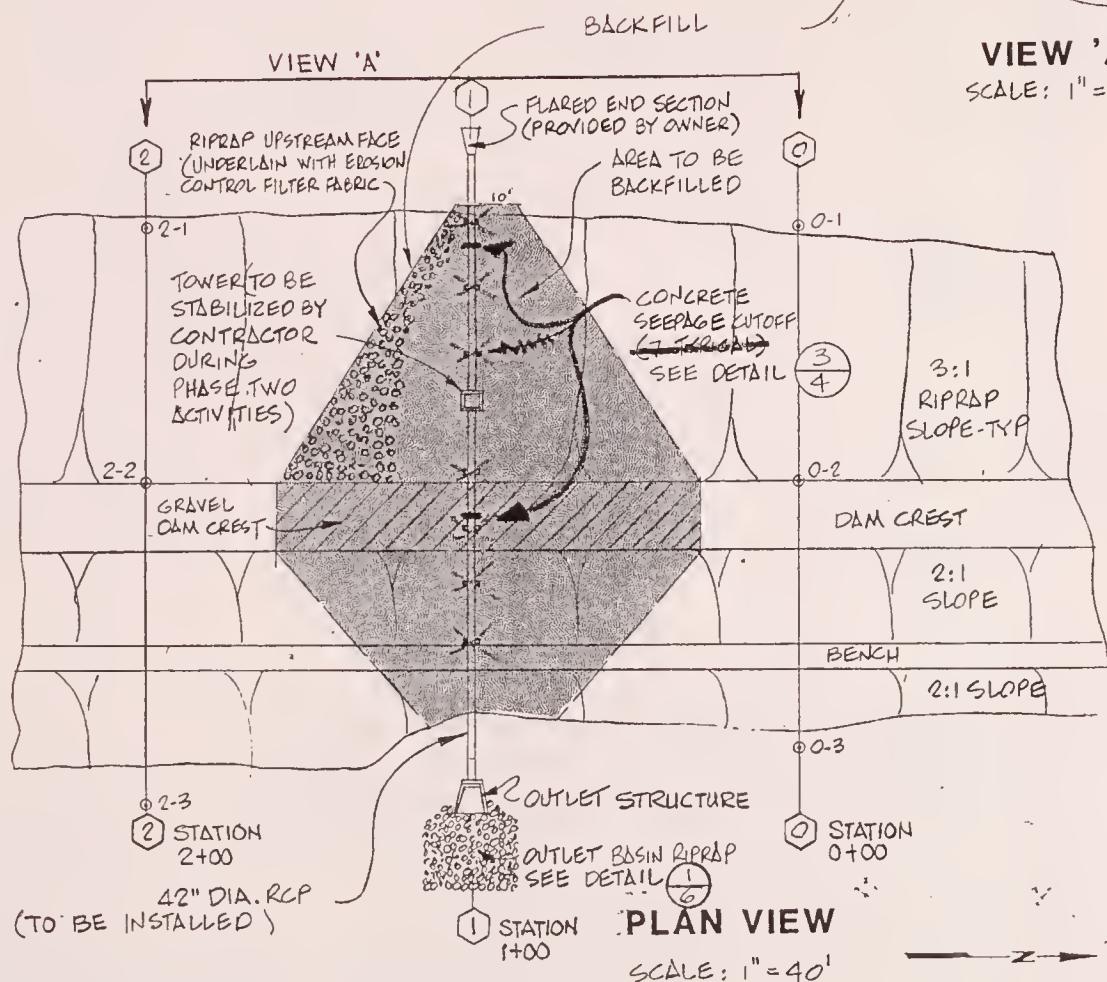
MORRISON-MAIERLE, INC.
CONSULTING ENGINEERS

1

5-166-9

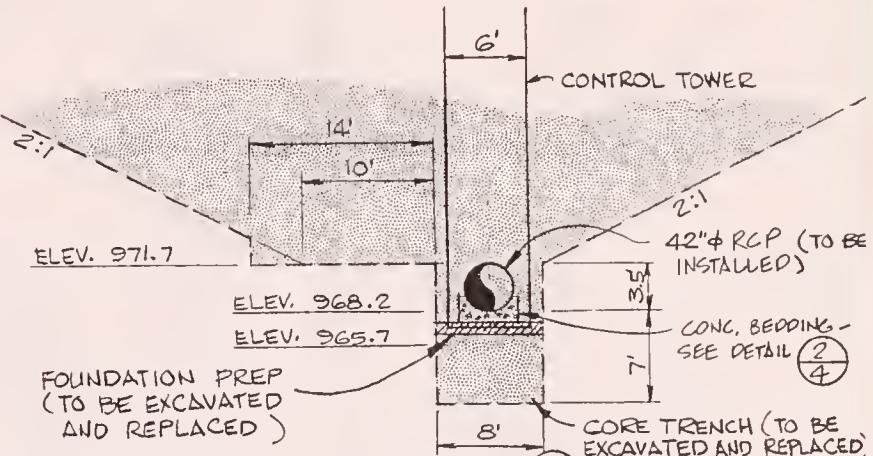
E8 2007

REFERENCE PIN
ELEVATIONS @
0-1 982.59
0-2 999.63
0-3 978.99
2-1 977.11
2-2 999.19
2-3 966.99
CONTROL TOWER
ELEV. 999.00



6 INCHES THICK AT STATION
1+00 TAPERING TO 2 INCHES
THICK AT STATIONS 0+30
& 1+60

VIEW 'A'
SCALE: 1" = 20'



DETAIL (1/2)
SCALE: 1" = 10

**DEPARTMENT OF NATURAL RESOURCES
& CONSERVATION**
DNPC PROJECT NO. 166.002

**YELLOW WATER DAM
OUTLET REPLACEMENT
PHASE TWO**

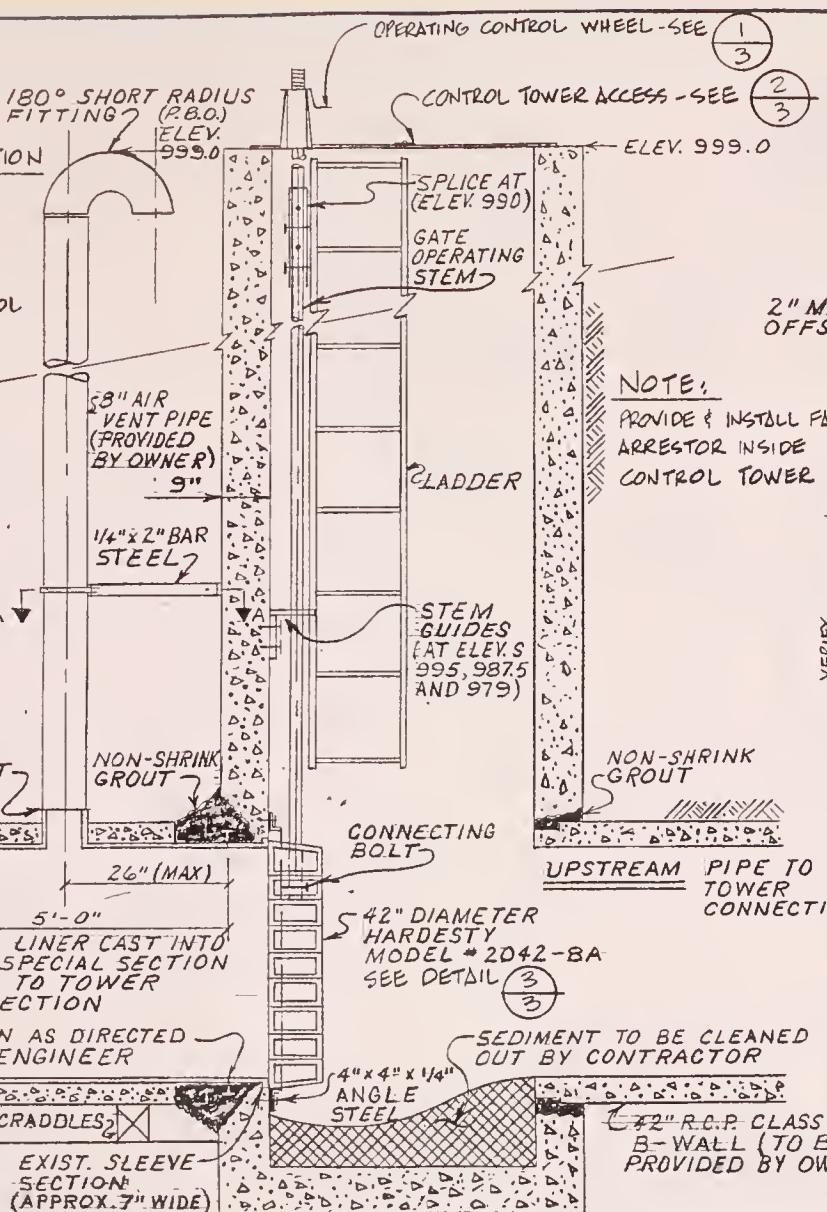
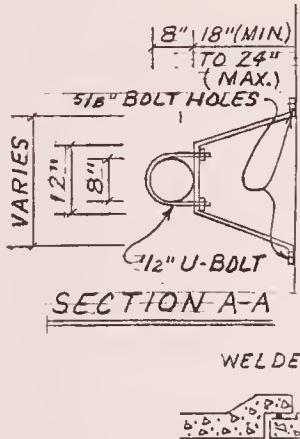
EXCAVATION VIEWS

| APPROXIMATE QUANTITIES | |
|------------------------|-----------|
| EMBANKMENT | 5700 CY. |
| UPSTREAM RIPRAP | 350 C.Y. |
| EROSION-FILTER FABRIC | 1000 S.Y. |
| GRAVEL CREST | 92 C.Y. |
| FOUNDATION PREP | 50 C.Y. |
| OUTLET STRUCT. | 18 C.Y. |
| OUTLET RIPRAP | 50 C.Y. |
| PIPE PLACEMENT | 184 PT. |
| PIPE BEDDING (CONC.) | 45 C.Y. |
| CUTOFFS (CONC.) | 10 C.Y. |
| EMBANKMENT DRAIN | 14 C.Y. |
| PIPE DRAIN | 22 C.Y. |
| FINISH GRODING | 2 AC. |
| OUTLET RIPRAP BEDDING | 25 C.Y. |

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CONSULTING ENGINEERS

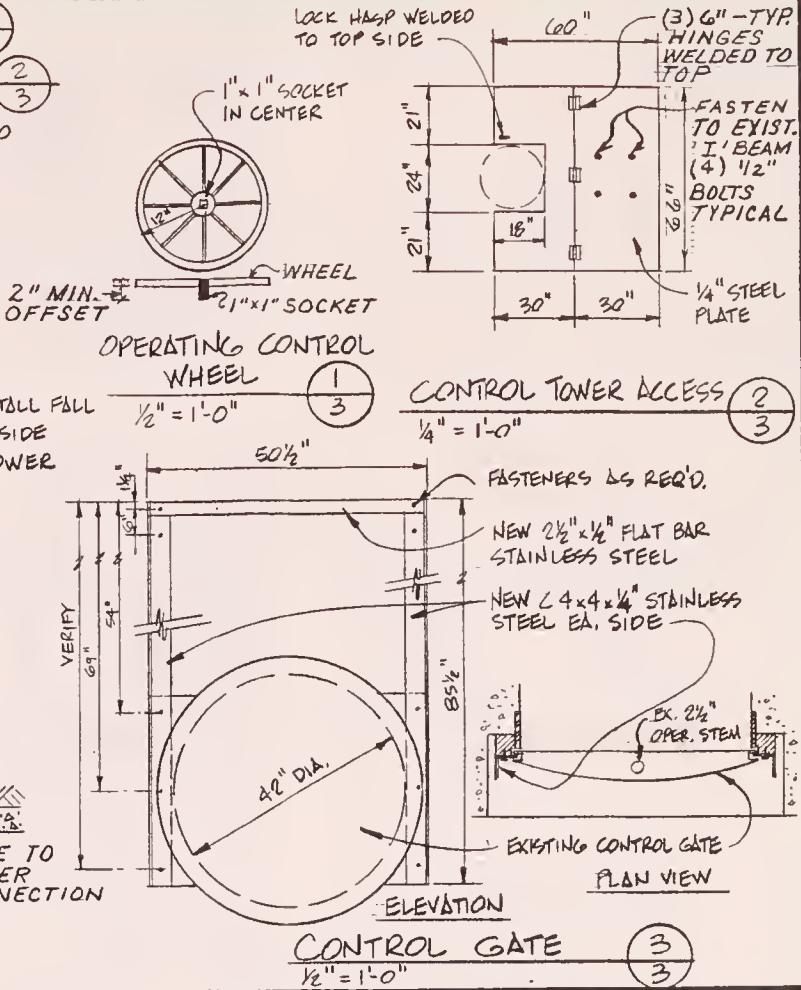
DRAWN
JMH
DESIGNED
PPP
DATE
9-23-85
PROJECT NO
1447-02-0
SHEET NO
2

AIR VENT INSTALLATION
CONTRACTOR TO APPLY 2 COATS OF RUST INHIBITING PAINT TO EXPOSED AIR VENT PIPE, CONTROL TOWER ACCESS HDG & OPERATING CONTROL WHEEL



CONTROL TOWER DETAILS

SCALE 1" = 20'



DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
DNRC PROJECT NO. 166.002

YELLOW WATER DAM
OUTLET REPLACEMENT
PHASE TWO

CONTROL TOWER DETAILS

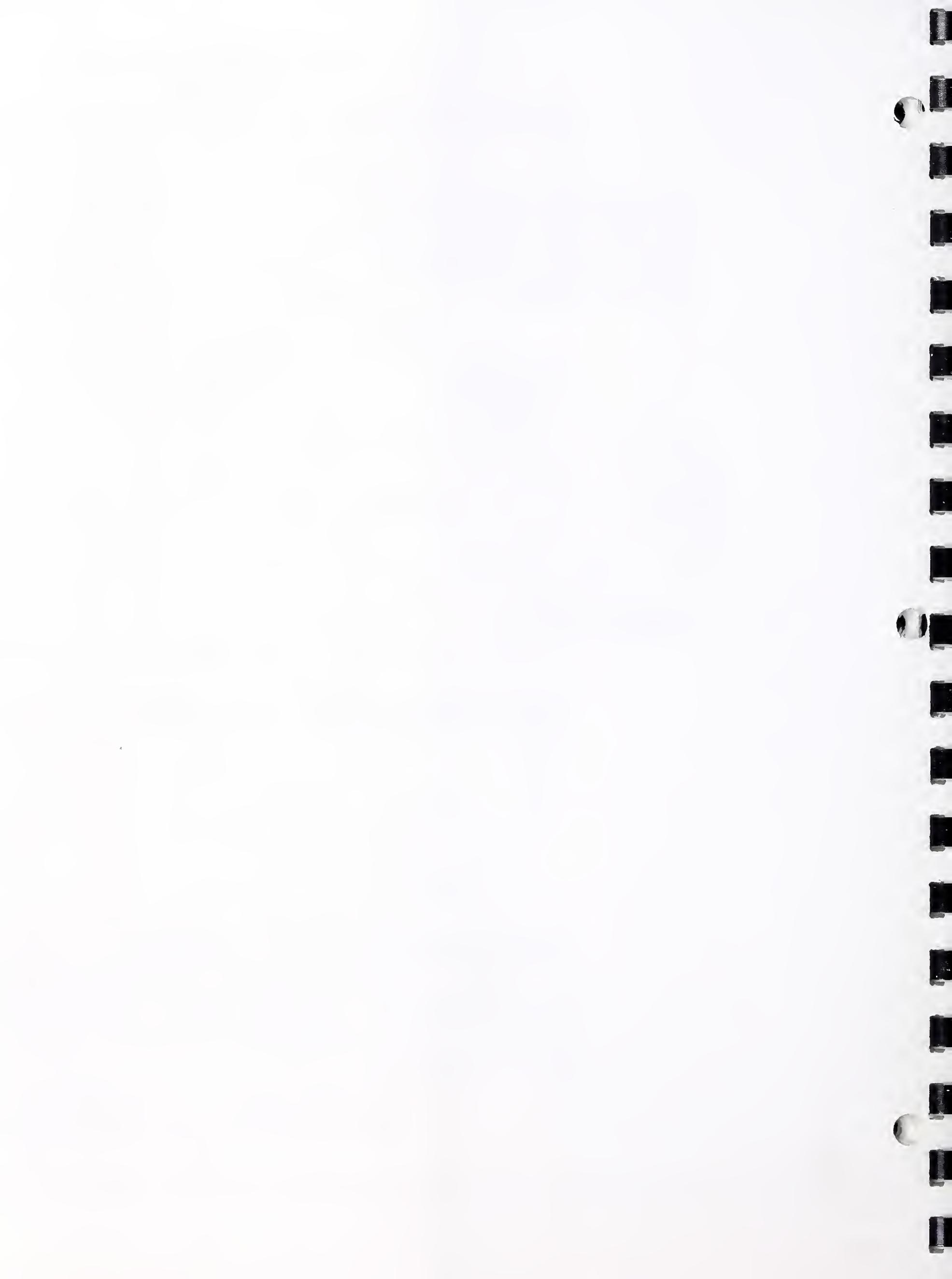


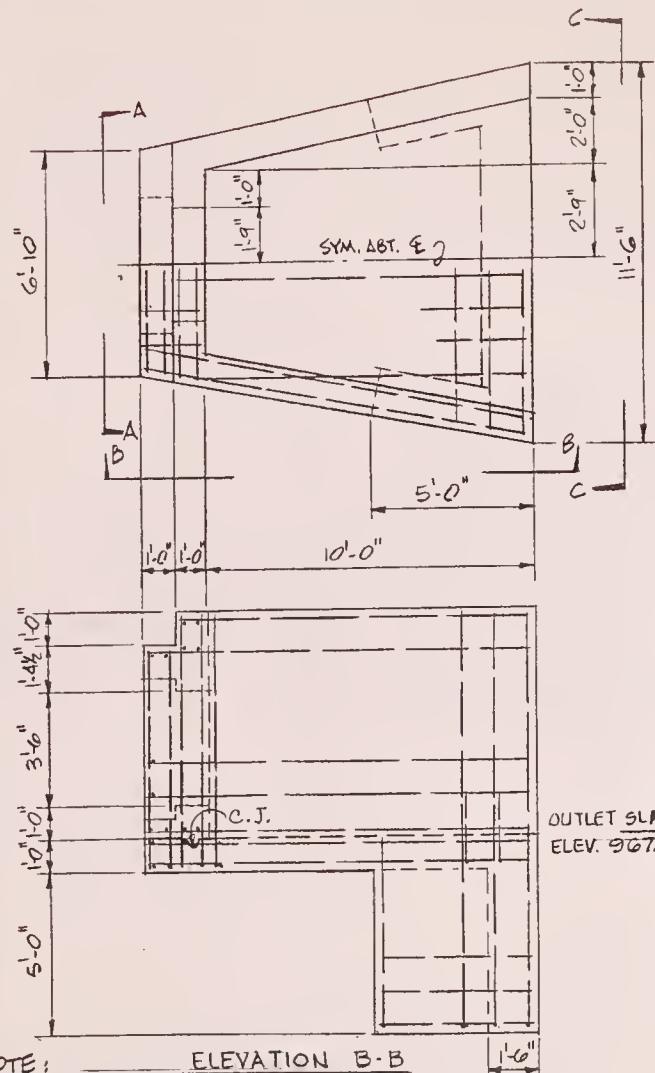
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DESIGNED
PPB
DATE
9-23-85
PROJECT NO.
1447-012-01
SHEET NO.
3

5-166-11

E10 2007

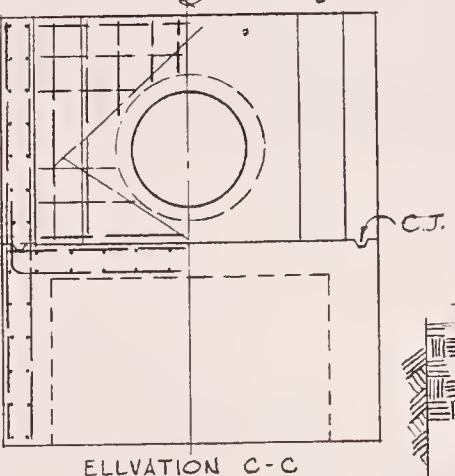




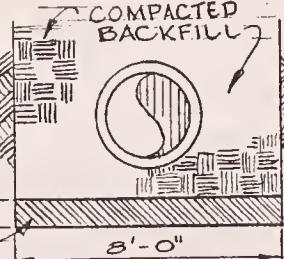
NOTE: ELEVATION
- ALL REBAR IN WALLS, PTGS.
& SLABS SHALL BE
#4 @ 12" EA. WAY
EA. FACE - GRADE GO
- PROVIDE FOR 15" LAPS
AT CONSTRUCTION JOINTS

- AT ALL WALL INTERSECTIONS
- PROVIDE CORNER BARS TO
- MATCH REINFORCING

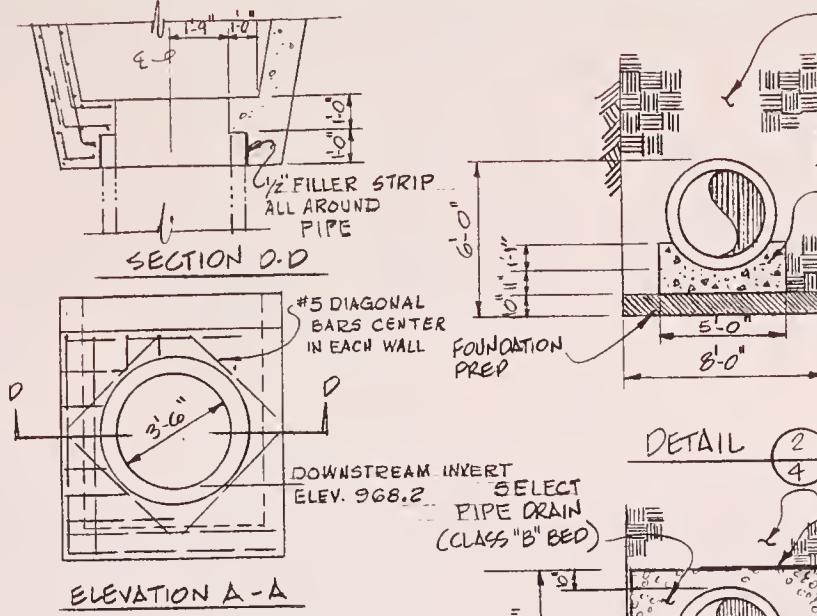
OUTLET STRUCTURE DETAILS



FOUNDATION PREP.



DETAIL (6)
4.



DOWNSTREAM INVERT
ELEV. 968.2 SELEC
PIPE DRAIN
(CLASS "B" BE

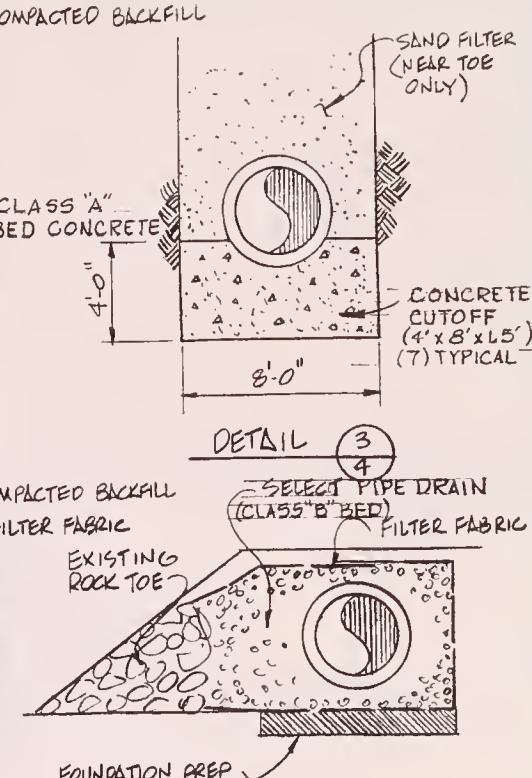
FOUNDATION PREP

DETAILS

DETAIL

CONCRETE
CUTOFF
(4' x 8' x 15')
(7) TYPICAL

SAND FILTER
(NEAR TOE
ONLY)



FOUNDATION

DETAIL 5
4

4 PIPE BEDDING DETAILS

**DEPARTMENT OF NATURAL RESOURCES
& CONSERVATION**
DNRC PROJECT NO. 166.002

YELLOW WATER DAM
OUTLET REPLACEMENT
PHASE TWO
OUTLET STRUCTURE &
PIPE BEDDING DETAILS

DRAWN
JMH

DESIGNED
PPP

DATE
9-23-85

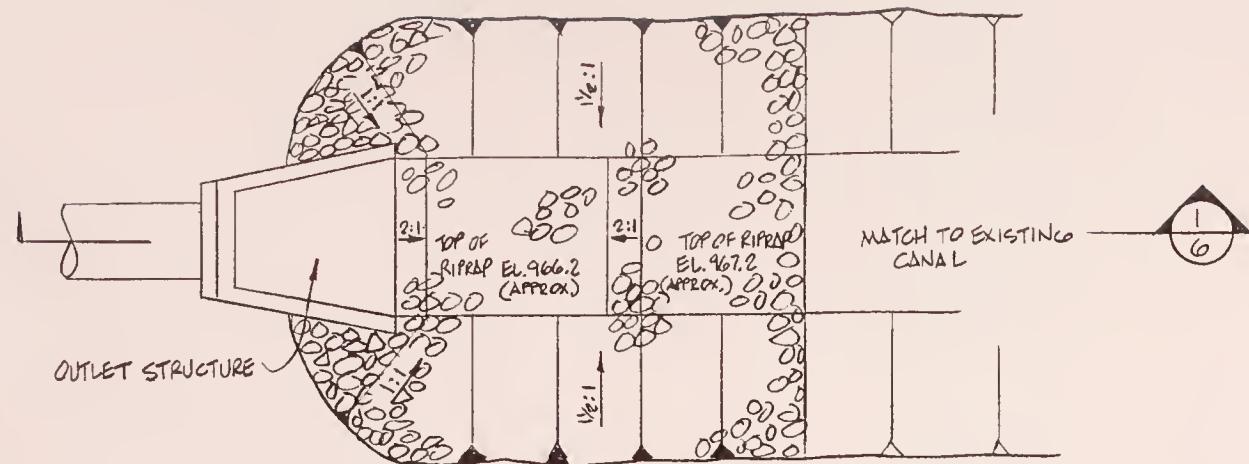
PROJECT NO
1447-012-01

SHEET NO
4

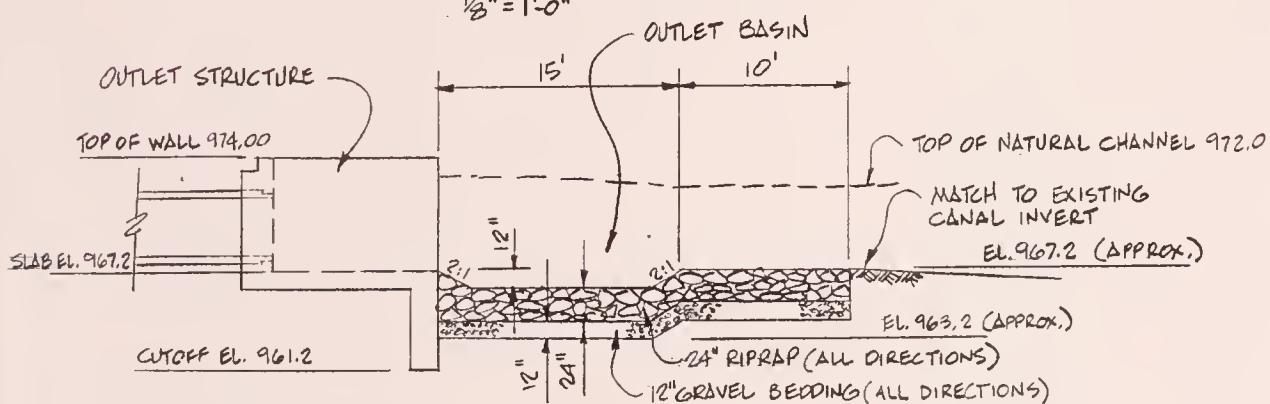
4







OUTLET BASIN PLAN



SECTION

1/8" = 1'-0"

1
6

DEPARTMENT OF NATURAL RESOURCES
& CONSERVATION
DNRC PROJECT NO. 166.001

YELLOW WATER DAM
OUTLET REPLACEMENT
PHASE TWO
OUTLET BASIN DETAILS

DRAWN
JMH
DESIGNED
PPP
DATE
9-23-85
PROJECT NO.
1447-012-01
SHEET NO.
6



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CONSULTING ENGINEERS

5-166-14

E13 2007

